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AN EXPERT SYSTEM FOR SELECTING ROOFING TYPES IN DEVELOPING AREAS

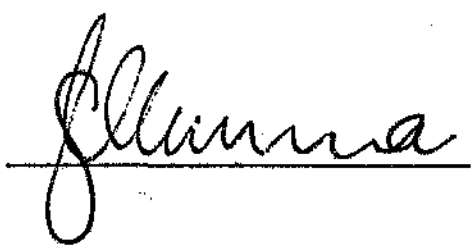
Silvia Da Conceiçao Cunha Oliveira

A project report submitted to the Faculty of Engineering, University of the Witwatersrand, Johannesburg, in partial fulfilment of the requirements for the degree of Master of Science in Engineering.

Johannesburg, 1993

DECLARATION

I, SILVIA DA CONCEIÇÃO CUNHA OLIVEIRA, hereby declare that this project report is my own, unaided work. It is being submitted for the Degree of Master of Science in Engineering in the University of the Witwatersrand, Johannesburg. It has not been submitted before for any degree or examination in any other University.



20th day of September 1993

To the animals at the Wits Animal
Unit who senselessly suffer and die
in the name of 'Science'

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ABSTRACT

This dissertation has as it's objective to develop an expert system for the purpose of investigating the suitability of using expert systems in developing areas. It is the first time to our knowledge that an expert system has been tested for usage in such a context. The housing and more specifically roofing domain is investigated for an application topic resulting in "the selection of suitable roofing types" being chosen. Potential end-users are identified, an appropriate context of such a system is outlined and an expert system tool is selected. The knowledge engineering and building of the knowledge base are described.

Feedback from the parties involved in testing and validating BUILDROOF is documented. In addition the suitability of using expert systems in the developing areas context in which BUILDROOF was developed, is discussed.

Finally, recommendations regarding potentially suitable areas of application for expert systems in developing areas are outlined.

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1. INTRODUCTION

1.1 IDENTIFICATION OF THE PROBLEM AND PROCEDURE SELECTED FOR THE STUDY

It has been said that 54% of projects in sub-Saharan Africa sponsored by the World Bank during 1979-1983 have been considered failures by the Bank itself [1] and that institutional failures, project design failures and policy failures are the most fundamental reasons for project failures in the Third World.[2] Such failures translate into an astonishing loss of time and money.[3]

The successful projects however reflect that at least in some cases, appropriate procedures and technology appear to have been adopted. It therefore appears that in order to increase the success rate in these areas, these experts' valuable expertise need to be preserved and used as a guide, so as to improve learning and understanding amongst others involved in similar projects in these areas.

An expert system is a computer program that models the valuable knowledge and reasoning processes of a human expert in some well defined problem area. It is able to perform problem solving and make reasoned deductions for the user from information supplied in response to questions. Conclusions usually take the form of advice supported by a structured argument based on the particular knowledge that the expert

system has supplied in a given case. Since this human expertise is encapsulated as software, it can be widely disseminated.[4,5]

Expert systems can be used to improve productivity, save time and money by solving problems in a timely manner and by avoiding costly mistakes and bad decisions; and they can be used to preserve valuable knowledge and improve learning and understanding.[6] Bearing in mind these benefits, their growing usage in industry appears logical. Similarly, it appears plausible that expert systems could play an instrumental role in replicating expert knowledge in developing areas. However, a literature survey carried out failed to reveal any documentation on applications of expert systems in this context.

The purpose of this study is to serve as a pilot study into the suitability of expert systems in developing areas. It was decided that this could best be investigated by developing an expert system to be used in this scenario. A topic of application thus had to be selected.

1.2 SUMMARY OF THE REPORT

Housing is an integral part of the socio-economic and political structure in a country. Adequate housing is a prerequisite for stability, welfare and mutual understanding.[7] One of the most pressing problems faced in South Africa today, is the ever increasing housing deficit.[8,9] Housing was therefore singled out for further investigation with regards to identifying a suitable topic of application.

Details and findings of this investigation are documented in chapter 2. By investigating the breakdown of housing costs and the availability of relevant expertise, roofing was identified as being worthy of further investigations with regards to an expert system application. Current roofing trends in formal and informal housing were investigated. A literature survey revealed alternative/suitable roofing technology and potential reasons as to why this technology is not being used on a larger scale are put forward. This led to a realistic, feasible context for such an expert system being outlined. In the scenario as defined, the development of an expert system to aid and advise an end-user in selecting a roofing type which is best suited to their needs, wants and limitations appeared plausible. Finally potential organisations and end-users offering an organisational structure into which such an expert system could be incorporated, are discussed. Thus an application topic has been identified, i.e. an expert system for selecting roofing types in developing areas.

In chapter 3, software tools were investigated with regards to their suitability to the application identified. Various factors are investigated in order to determine the most suitable development choice and once this is identified as being the usage of a shell, the selection of an actual shell is done. In order to obtain a relatively solid indication as to what form the knowledge base should take and thus the suitability of the shells being investigated a portion of the knowledge engineering (as discussed in chapter 4) was done in conjunction with this chapter. This chapter concludes with the EXSYSPro shell being selected as a development tool.

The process of performing the knowledge engineering and building the knowledge base, is discussed in chapter 4. This involves the gathering of desired knowledge (from both literature and human expertise) and the formatting of this knowledge into a knowledge base. From the literature

survey, various roofing types are investigated. These are then sub-divided into 4 categories, of which only two categories, units and systems, are selected for inclusion in the expert system due to time constraints. The goods and services required and the features offered by each roofing type are investigated and documented. Factors considered when selecting a roofing type are also identified. Human expertise is used for analysing and verifying the sub-domains identified from the literature survey and for developing an outline of these sub-domains by placing them in a hierarchy. Additional requirements of the package are identified by the expert and potential end-users.

Finally, facilities offered by the EXSYSPro shell for meeting the requirements as identified, are discussed.

In Chapter 5, each of the options offered in the BUILDROOF menu is discussed i.e. running BUILDROOF, outputting results, changing location, input of data on availability of goods and services, data on actual costs returned and inputting of new roofing types. Specific attention is given to the reasoning process and the use of variables, qualifiers and frames.

Chapter 6 documents feedback from the parties involved in the testing and validating of BUILDROOF as well as feedback on the suitability of expert systems in the developing areas context for which BUILDROOF was developed. Potentially suitable application areas identified are documented.

Finally, in chapter 7, conclusions reached and recommendations are drawn up.

1.3 LIMITATIONS OF THE STUDY

Certain limitations applied to this study and these should be borne in mind especially when analysing the feedback and conclusions.

(i) The purpose of this study was to investigate the suitability of expert systems in a developing areas context. The feedback and findings are however influenced by:

* the one single application topic i.e. selecting of roofing types in developing areas; and
* the views expressed by a small pool of experts and potential end-users.

(ii) In turn, the validity of the actual package developed, BUILDROOF, was limited by:

* the knowledge representations and reasoning mechanisms provided by the software used to develop it i.e. EXSYSPro; and
* the scope thereof which was limited to two roofing types in each of the two categories catered for i.e. The EFU and USSR ranges for UNITS and concrete troughs and concrete blocks for SYSTEMS.

2. ROOFING DOMAIN

This chapter is an overview of housing with the intentions of investigating an appropriate area for expert system application.

2.1 HOUSING IN SOUTH AFRICA - PAST AND PRESENT

The method by which housing has been 'delivered' to the unhoused has changed dramatically over the years. The policy has changed from one where the government let housing to those eligible to be permanently housed in South Africa, to the recently adopted policy of encouraging the private sector to take complete responsibility for housing all except the indigent.[10]

The previous policy has however left it's mark on the housing scenario. The number of housing units occupied by the black population group has never been counted in any of the national censuses and so no precise statistics are available on the magnitude of the housing backlog. The Urban Foundation has however estimated the current shortage as being approximately 1.8 million units, and estimates that this will increase to approximately 4.7 million units by the year 2000. (This number is arrived at by taking into account current rates of population growth and supply of new units). This translates into a need to provide 390 000 units annually

in order to meet the demand in the year 2000. This target is nowhere near being met by the current rate of supply.[9,10]

The shortage of housing and related community facilities together with the current unemployment figures (estimated at 45% of the formal sector[11]) for the low-income communities in South Africa, remain among the most critical political and social issues that still need to be addressed.

2.2 BREAKDOWN OF HOUSING COSTS

The solution is however not an easy one, as there are many interrelated factors which have to be considered, the most important of which is affordability. This is the relationship between the income of the people (and therefore what they can afford) and the economic cost of their housing needs. This is the greatest challenge in providing housing.[12]

Housing costs can be broken down into 3 broad categories (See figure 2.1):

* Land and Infrastructure costs
* House costs
* Ongoing monthly charges for services consumed

Unless all three categories are considered together, effective solutions cannot be achieved. While being of equal importance, the first and third categories are however outside the scope of the current investigation.

The cost of the house itself is controlled or determined by the following factors:

* Financing
* Delivery systems
* Construction technology

As in the previous case, all three factors need to be considered together in order to arrive at an effective solution. However, although financing and delivery systems are imperative for an effective solution, they are also outside the scope of this project.

Construction technology incorporates the following:

* Substructure - foundations and foundation walling
* Superstructure - walling and
* Roofstructure [8]

Under normal conditions, roofing is the most structurally complicated of the three. In addition, roofing offers the greatest and most immediate protection against the elements. It is therefore considered to warrant further investigation with regards to an expert system application.

2.3 CURRENT ROOFING TRENDS IN FORMAL & INFORMAL HOUSING

In order to assess what an expert system on roofing should concentrate on,

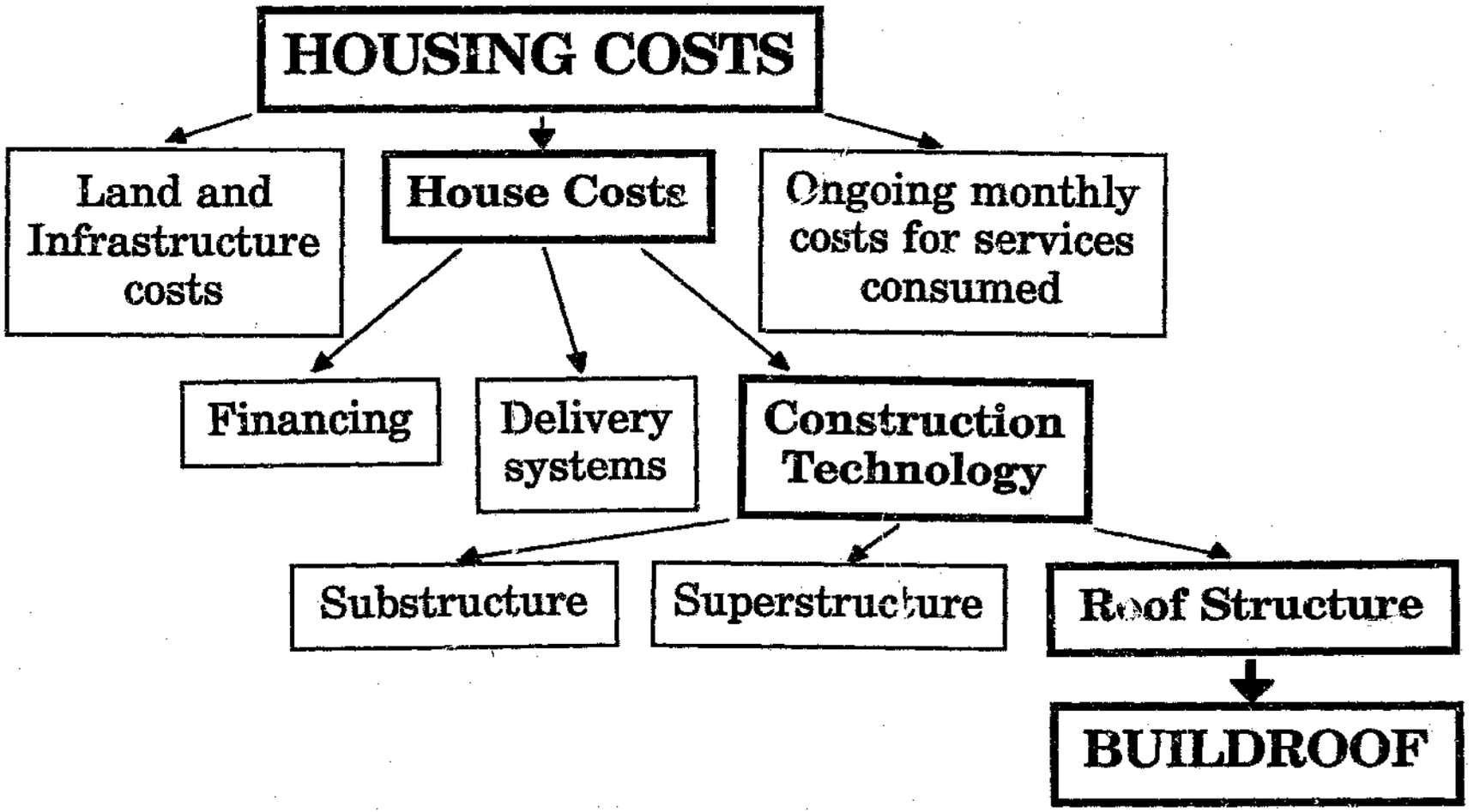


Figure 2.1 **Breakdown of housing costs**

an overview of current roofing trends across the broad spectrum of both the formal and informal (housing alternatives which are not part of an official government housing programme) housing sectors, was investigated.

2.3.1 FORMAL HOUSING

This sector is largely serviced by formal contractors. Roofing types commonly used are conventional trusses with conventional coverings of tiles, sheeting etc. In a few cases, rafters are used together with the coverings mentioned above. Trusses and coverings are almost exclusively designed by experts, manufactured in factories and thereafter delivered to site. This process is obviously costly to the purchaser and money paid for such components leaves the community immediately.

2.3.2 INFORMAL HOUSING

Due to the lack of money, the informal housing sector is largely serviced by self-builders. Roofs are erected making use of whatever is available. Attempts are made at copying conventional roofing systems. This trend has common repercussions:

* because it is a replica of the original (without the expertise), it is often structurally unsound with poor utilisation of materials;
* roofs cannot be upgraded;
* roofs cannot be extended;
* because conventional roofing types are not necessarily aimed at making use of local resources (be they goods or

services), the financial repercussions are carried by the home owner;

* roofing components are often manufactured outside of the community, therefore money leaves the community and
* roofs are not climatically suited to the location.[13]

2.4 ALTERNATIVE ROOFING TYPES AND EXPERT SYSTEMS

The need to provide affordable housing for low-income communities has highlighted the need for a diversity of strategies and innovative building techniques to help cope with the resultant challenge.[14] An essential requirement of this appropriate/alternative technology is that it should lead to technical solutions which are consistent with the capabilities and lifestyle of the population and that it should make the best use of labour, materials and other economic resources of the society.[15]

A substantial amount of research into various alternative roofing types has been carried out by research institutes such as the CSIR. Similarly, information on roofing types developed in other countries has also been documented. As a result an impressive quantity of literature on alternative roofing types aimed at low-cost housing, and the informal housing sector in particular, is available.[13,16]

However, it is believed that it is because of the lack of attention that has been paid to the factors mentioned in section 2.2 (e.g. finance, delivery systems etc.) that alternative roofing types have not been marketed on a significant scale. This has advanced the lack of knowledge on alternative roofing types and has largely contributed to the reason why the informal housing sector continues 'attempting' to build prototypes of conventional roofs as apposed to adopting alternative roofing technology.[13]

2.5 SUITABLE CONTEXT OF AN EXPERT SYSTEM

In section 2.2 it was pointed out that apart from appropriate technology, other factors exist which are imperative to meeting the housing deficit. It is therefore of no use investigating an appropriate expert system for roofing, without setting it in a realistically feasible context. The assumption will therefore be made, in developing and justifying the expert system - BUILDROOF - that these other factors, which are outside the scope of this project, have been adequately resolved.

2.6 EXPERT SYSTEM APPLICATION IN ANTICIPATED ROOFING SCENARIO

Assuming a scenario as outlined in section 2.5, the marketing of suitable roofing types would improve automatically. The ease with which each

roofing type could be marketed would be dependant on how much preparatory work has been done i.e. the extent to which the process of design and testing thereof have been completed. The main priority of the potential home owner would then be to be thoroughly informed when selecting a roofing type. This requires neutral, non-biased advice based on thorough familiarity with details of the range of roofing types available so as to aid an end-user in selecting a roofing type which is best suited to their needs, wants and limitations.

However, few experts exist who are adequately familiar with the wide variety of roofing types so as to successfully be able to advise individual end users on the most appropriate roofing type for them. This information is limited to experts on individual roof types. A reservoir of knowledge is only as useful as the ease with which it can be found, understood, interpreted and used. Therefore this expertise and alternative technology, is largely either too expensive to obtain or not necessarily in a form usable by the end-user. The available information is thus not reaching the appropriate market.

This situation is not unique. Experts in most fields are a rare commodity; because there are few of them, they are typically in great demand and their valuable expertise is often unaffordable to any except large scale financiers. A solution to this dilemma could be achieved by developing a clone of the expert by some means such as an expert system. An expert system is simply a computer software representation of an expert or group of experts.[6] Expertise is represented by means of searching sets of rules or databases for solutions to specified problems. The rules or databases used are developed from careful assessment of available expertise, and are checked for compliance with expert opinion on any problem which might be posed.

Thus the development of an expert system to aid in selecting roofing types in developing areas appears to offer a plausible solution.

2.7 ORGANISATIONS INVOLVED AND POTENTIAL END-USERS

Obviously, due to the nature of the end-user market, individuals are not going to purchase BUILDROOF for use at home on personal computers. Therefore BUILDROOF needs to be available to end-user's through another path. This can be done by incorporating it into a structure that already exists.

A number of organisations exist that are involved in housing. Most of the contractors/consultants who were consulted at these organisations agreed that there was a need for alternative technology for low-cost housing (costing in the region of R5 000,00). However, they felt that due to the politically volatile nature of the informal housing sector areas at present as well as the low levels of profit to be made, and the fact that there still appears to be enough work in the formal, higher income areas, they do not see it as being a feasible option. This further supports the theory that if the housing deficit is to be met, it will be achieved by small scale contractors and predominantly self-builders.[13,17]

Of the organisations consulted, only two were actively involved in training and developing small scale contractors, artisans and self-builders for working in low cost housing. They were therefore the only organisations

that warranted further investigating as potential BUILDROOF users:

* IDT (Independent Development Trust) in conjunction with TACs (Technical Aid Centres)
* ABA (African Builder's Association)

2.7.1 INDEPENDENT DEVELOPMENT TRUST (IDT)

(a) Background

The Independent Development Trust (IDT) is a non-government development organisation established specifically to address the social upliftment of very poor people in South Africa. The intention to establish this R2 000 million trust to be administered independently of the state was announced by the State President on the 16th of March 1990.

The IDT is administered by a Board of Trustees which comprises of a wide range of South African leaders across the political and socio-economic spectra.

(b) Objectives

One of the four development areas where the Trust initially decided to focus its support was on housing, especially shelter for the poor and the people living in informal settlements.

The Board of Trustees, together with a small staff, identified organisations which would be responsible for turning these policies into practical, on the ground programmes. The Trust is thus working as a development agency. It provides financial and other support on a

meaningful scale for the activities of the organisations. These in turn will manage or co-ordinate the individual projects and programmes through which the Trust hopes to achieve its primary goals.

In addressing the first of the four development areas outlined previously, the Trust allocated approximately R750 million towards assisting families who wish to purchase a serviced site in a site-and-service scheme or informal settlement upgrading scheme by providing a capital subsidy of R7 500 on the selling price of a site in such schemes. 108 developers involving 99 800 sites have been approved.

Broadly speaking, the main objective of the IDT is to achieve consolidation in its chosen communities. Consolidation being the process of the upgrading of informal communities in both physical environmental terms and in socio-economic terms. As consolidation proceeds housing is upgraded from informal to formal structures, infrastructure services are improved, public and private sector community facilities are provided, commercial enterprises are established, the skills of the community are improved thus facilitating increased income generation in the community, friendship networks are established, social programmes are initiated, and so on.

One of the factors which has been identified as an important condition for successful consolidation is access to building materials and advice.

It has been suggested that Technical Aid Centres (TACs) be introduced at the outset of a project in order to provide these.

Functions carried out by the TAC would include, amongst others, the following:

* to advise on house designs i.e. foundations (sub structure), super structure and the roofing system;
* to supply technical information on above mentioned points;
* the possible inclusion of a materials yard and
* to serve as a community centre where information on available goods and services can be obtained.[13,18,19,20,21]

2.7.2 AFRICAN BUILDER'S ASSOCIATION (ABA)

(a) Introduction

The African Builder's Association is a national non-government association which aims to promote and co-ordinate the involvement of blacks in the building industry as builders, contractors and developers.

ABA was formally established in 1987 by Mr Joe Mogale. At this stage it was confined to the Transvaal boundaries. Only with its more recent affiliated association to FABCOS (Foundation for African Business & Consumer Services) has ABA taken on a national status.

(b) Objectives

ABA documents the following (amongst others that are outside the scope of this analysis) as being its functions:

* to promote education and training among builders;
* to establish a marketing information centre, whereby information relevant to the trade is available;

Today, ABA has between 3 000 and 6 000 members. These are made up from the wide spectrum of contractors, artisans (e.g. plumbers, bricklayers etc.) and self-builders and are involved in both the formal and informal housing sector.

With its move into the national arena, ABA now has offices across the country. It's head office is in Pretoria. Regional offices exist in Johannesburg & Pietersburg in the Transvaal, Bloemfontein & Welkom in the Orange Free State, Durban & Newcastle in Natal and Cape Town & East London in the Cape.

These offices serve as Information Centres for the use of ABA members. Each office is staffed by at least one technically skilled person and is largely sponsored by private building suppliers. By co-ordinating with these sponsors, ABA promotes education and training among builders through training classes. It is also in the process of establishing building yards affiliated to the offices, where members will be able to obtain materials at reduced costs and simultaneously obtain technical information therein if necessary. Computers are available at all the offices.

Ideally, the personnel employed by ABA should be 'experts' in a variety of technical fields related to housing. However, due to the scarcity of such experts and to the very nature of the market in which ABA operates (low-cost housing), financial constraints inhibit ABA from employing such personnel. ABA has tried to compensate for this by supplying this 'expertise' in the form of papers, books, manuals etc. These appear to be in an unusable form though. ABA's president, Mr Mogale, sees this as being one of the major problems with which the office managers are having to contend.[17]

2.7.3 SUITABLE IMPLEMENTATION OF BUILDROOF

It appears that BUILDROOF could be successfully implemented into the structure of the TACs as well as ABA. In this way, it could supply information and guidance to IDT recipients and ABA members when selecting a roofing type.

It is anticipated that the running thereof would require one 'computer operator' having a basic understanding of computers and a standard computer. A 'BUILDROOF USER'S MANUAL' was compiled to guide the operator on how to utilise the BUILDROOF package. (See Appendix B for 'BUILDROOF USER'S MANUAL').

This operator would be required to assist the end-user in the using of the BUILDROOF package. A 'BUILDROOF VISUAL GUIDE' was compiled so as to assist the end-user in selecting acceptable

roofing types. (See Appendix C for 'BUILDROOF VISUAL GUIDE').

2.8 SUMMARY

Considering the shortage of housing, the unemployment figures, and the characteristics of conventional and alternative roofing technology, it is apparent that a market exists for alternative roofing technology. This technology is available. However, due to factors which are beyond the scope of this project, it has not been marketed on a significant scale. Assuming a scenario in which these factors have been given the attention that they so critically require, the main priority of the end-user would then be to obtain neutral and non-biased advice and guidance from a body which is thoroughly familiar with details of the range of roofing types available. The end-user would thus be aided in selecting a roofing type which is best suited to their needs, wants and limitations.

Therefore, the basic problem is the transfer of knowledge and advice to the self-builders, artisans or small scale contractors by the encapsulating and moulding of knowledge into a usable form. It therefore appears reasonable and appropriate to develop an expert system for selecting roofing types in developing areas.

3. SELECTING AN EXPERT SYSTEM TOOL

3.1 OVERVIEW

The process of selecting which software tool to use is a major decision in the development process. This process, as depicted in figure 3.1, can be roughly divided into two major sections, the development choice and then depending on this outcome - the selection of which shell, AI language or conventional programming language to use.

The decisions made in the two sections are dependant on several factors, some of which influence both sections:

* programming capabilities;
* time available;
* objective of work to be done;
* type of computer system on which system is to be developed as well as the host user's computer;
* nature of the problem itself and
* funds available.

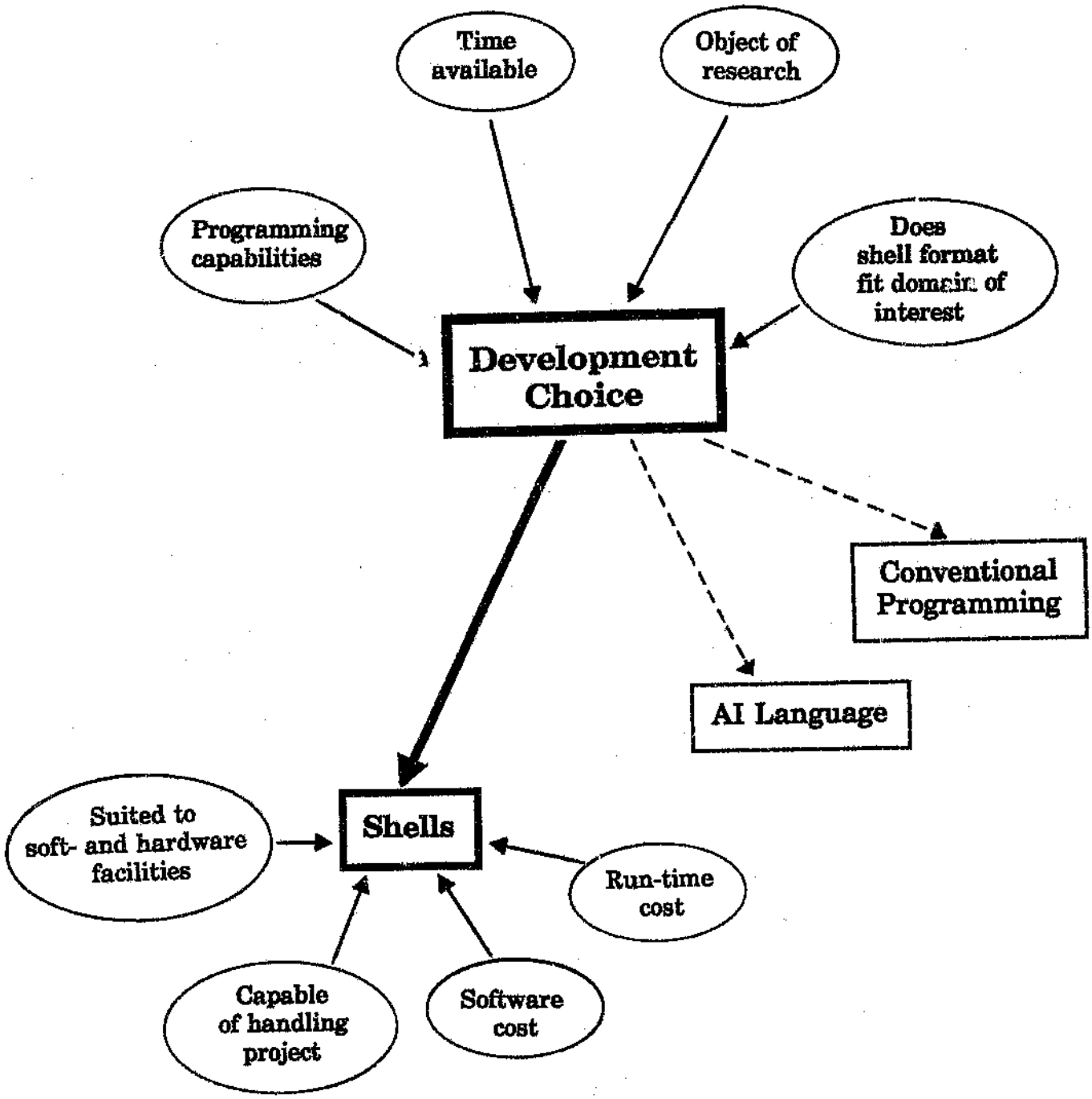


Figure 3.1 **Selecting an expert system software tool**

3.2 THE DEVELOPMENT CHOICE

The first step was to evaluate the author's programming capabilities. The only programming language with which the author had had experience was Turbo Pascal. Nevertheless, programming an expert system from scratch would have been an enormous undertaking and the time involved in learning another language well enough to create an expert system would have been consuming. In addition, the crux of this research was not to program an expert system, but to develop an expert system and collect feedback on the suitability of it's topic and area of application. It therefore appeared that if the last condition was also met i.e. that the shell format fit the knowledge domain, then the fastest and easiest approach would be to use a shell.

In order to assess the suitability of a shell's format to the knowledge domain, a more solid indication as to what form the knowledge base should take, was needed. It was therefore decided to defer the step of development process until a small amount of the next step (i.e. the knowledge engineering) had been completed, the details of which are documented in chapter 4.

From this preliminary investigation, the following software facilities were identified as being necessary:

* support of IF-THEN-ELSE production rules;
* access to data storage facilities - either 'in-house' e.g frames, or compatibility to external database software;

* an enhanced command language;
* support of both forward and backward chaining;
* hypertext / help facilities and
* development of custom screens.

These facilities were found to be offered by most shells. It was therefore decided to use a shell as a development tool.

3.3 SELECTING A SHELL

3.3.1 CRITERIA FOR SHELL SELECTION

The following factors were considered when selecting a suitable shell:

* The shell should be large enough and capable enough to handle the project that the author had in mind - capability being measured by it's ability to meet the requirements as outlined in section 3.2.

* The shell should be suited to the author's, as well as the end-user's soft and hardware facilities. The author worked on an IBM compatible 386 PC and had most standard software available. Potential end-users's hardware facilities were mostly IBM compatible 286s and their software was mostly limited to an MS-DOS version.

* The software cost should not be excessive.

* Due to the very nature of the target market, the run-time cost should be as low as possible.

* The software should be expandable and flexible. It should, for example, be possible to incorporate a times analysis package.

3.3.2 SHELL COMPARISON

Information pertaining to the criteria for selection of shells as outlined in section 3.3.1 was collected on several shells. These details are documented in table 3.1.

SHELL	MEET SECTION 3.2 REQUIREMENTS?	SHELL SUITS SOFT- AND HARDWARE?	SHELL COST	RUN-TIME COST
Level5	Yes	No, require dBase III	Zero - A copy is available in the department	Approx. R1 000,00
Leonardo	Yes	Yes	R6 875,00	R1 500,00
EXSYSPro	Yes	Yes	R4 000,00	R120,00
XiPlus	Yes	Yes	R7 000,00	R1 650,00

Table 3.1 Comparison of expert system shells

All four shells met the requirements as identified in section 3.2. A copy of Level5 was already available to the author and so no development software costs would have been incurred. However, Level5 does not have 'in-house' data storage facilities and therefore requires compatible database software. None of the end-users approached had copies of the software and would thus have had to purchase copies thereof. Of the three remaining shells, EXSYSPro was the cheapest. It's run-time cost, which would effectively be carried by the end-user when purchasing the expert system, was also the cheapest by a substantial margin. Thus the final decision lay between EXSYSPro and Level5. This decision was made by comparing the actual shell and run-time cost carried by each end-user. The larger the number of end-users the more financially feasible the usage of EXSYSPro becomes as apposed to Level5. The break-even point was calculated to be 4.6 end-users. (See calculations below)

a = number of expert systems sold = number of end-users
4000/a = EXSYSPro shell cost to be carried by each end-user
Runtime cost of EXSYSPro = R120,00
Runtime cost of Level5 = R1000,00

Cost of EXSYSPro = Cost of Level5
4000/a + 120 = 1000
4000 = 880a
Therefore, a = 4000/880 = 4.6

Thus assuming a minimum of 5 end-users, EXSYSPro was shown to be the most cost efficient software to use.

3.3.3 CONCLUSION

On the basis of this criteria for selecting a shell and the shell comparison in section 3.3.2, it was decided to use the EXSYSPro shell to develop BUILDROOF.

4. PERFORMING THE KNOWLEDGE ENGINEERING AND BUILDING THE KNOWLEDGE BASE

4.1 INTRODUCTION

Once the expert system application area had been defined, the knowledge engineering could commence. This involved the process of gathering desired knowledge and thereafter formatting it into a knowledge base. The knowledge which was used came from two basic sources, literature and human expertise.

4.2 GATHERING OF KNOWLEDGE - LITERATURE

Documentation about the roofing type domain was obtained from various sources:

* technical papers [22,23];
* case studies of housing developments [24];
* books [16];
* magazine articles [25] and
* roofing manuals. [26,27]

By reviewing this literature, the following was obtained.

Firstly, an introduction to the following roofing types:

* conventional roofing types currently in wide use;
* roofing types that have already undergone the design process and are currently in the process of being marketed and
* roofing types that have undergone the design process but are not yet being marketed.

This introduction included an investigation of the goods and skills required for the manufacturing and erection of the roofing type as well as an overview of the features offered by each roofing type.

Secondly, an insight into the factors that were considered when selecting a specific roofing type for a certain end-user or group thereof.

4.2.1 ROOFING TYPES INVESTIGATED

(a) Categorisation of roofing types

The roofing types that were investigated were categorised into four different groups:

(i) Units

These roofing types are basically DIY type packages in which the components of a roofing structure are purchased and then erected by the end-user. Available in a variety of different sized building blocks (modules), they can be combined in various ways to form homes of assorted shapes and sizes (sub-units).

Units investigated were:

* Evertile Fast Frame Units (EFU) [26]
* Untiedt Support Strutt Roofing (USSR) [27]

(See Appendix A1 & A2)

(ii) Systems

These are roofs made up of smaller elements. Unlike the building blocks of the units, the elements (modules) can be constructed and erected by the end-user, provided the required moulds or forms are available.

Systems investigated were:

* Concrete troughs [16,22,23,24]
* Concrete blocks [16,22,23,24]

(See Appendix A3 & A4)

(iii) Rafters + covering

These consisted of either pole or rectangular timber sectioned rafters. These rafters could be arranged to form either a mono or pseudo double pitch. Coverings on these rafters varied between conventional and unconventional roof covering.

(iv) Trusses + covering

Trusses are constructed from either pole or rectangular timber sections. The lack of steel truss manufacturers in the housing market seems to indicate that steel trusses cannot compete with timber trusses at such short spans[28]. Both mono and double pitched trusses are available with pitches

being a function of the roof covering used. As for rafters, coverings varied between conventional and unconventional roof coverings.

Due to time constraints, it was decided that only two of the groups discussed would be incorporated into the BUILDROOF computer system for the purposes of this project. The units and systems were selected for the following reasons:

* they are the two which have been specifically designed with the limitations and constraints characteristic of the lower income sector in mind, and therefore are the most suited to this sector and
* they are the two groups which have been the least marketed and as a result on which the least usable information and advice is available.

It should be borne in mind that rules for rafters and trusses could be added at a later stage.

(b) Goods and skills required

Goods and skills required for manufacturing and/or erecting roofing types were categorised into the following groups:

(i) Modules

The actual building blocks of the roof i.e. building blocks in the case of the units and elements in the case of the systems.

With regards to the systems, the elements can be either purchased or self-manufactured. Then,

depending on the choice made in obtaining the elements, different goods and services are required.

(ii) Equipment

This incorporates standard equipment plus any equipment that may be required when self-manufacturing elements.

(iii) Materials

Materials that are required e.g. sand, cement, re-bars etc.

(iv) Tools

Standard tools that are required e.g. hammers, spanners etc.

(v) Skills

Different levels of skills required.

(See Appendix A1, A2, A3 and A4 for details and calculations of goods and services required for UNITS and SYSTEMS roofing types included in BUILDROOF)

(c) Features

Details obtained on the features offered by individual roofing types were categorised under the following headings:

(i) Ceiling

Three categories exist:

* ceiling included (included with units);
* ceiling not included but facilities for the installation thereof exist;
* ceiling not included and no facilities exist for installation thereof.

(ii) Gutters

As for ceilings above, three categories exist:

* gutters included (included with units);
* gutters not included but facilities for the installation thereof exist;
* gutters not included and no facilities exist for installation thereof.

(iii) Temporary housing

Suitability of a roofing type to being 'moved' to another site.

(iv) Core housing

Suitability of a roofing type for later extensions.

(v) Pitch

Three types of pitch exist:

* flat
* mono
* double

4.2.2 FACTORS CONSIDERED IN SELECTING OF ROOFING TYPES

From the literature survey, and the case studies in particular, the factors considered in selecting an 'appropriate' roofing type were identified as being the following:

(a) Climatic suitability

Roof types exhibit suitability to certain climatic conditions. The location in which the roof was to be erected therefore played a role in selecting a suitable roofing type. In addition two factors had to be considered:

* roofing types containing corrosive materials may not be suited to coastal regions. (A coastal region is defined as a 15 kilometre strip along the coast) and
* a ceiling may influence the climatic suitability of a roofing type to a location.

(b) Affordability

Roofing types were selected taking into consideration the financial constraints of the end-user.

(c) Utilisation of local goods and services

Maximum utilisation was made of locally available:

* material
* tools and
* skills

4.3 HUMAN EXPERTISE

Although the information gathered from the literature survey discussed in section 4.2 served as the master source of knowledge, it was the knowledge from the human expert, Mr Arrigone, that was instrumental in codifying the knowledge into a usable form and therefore creating the knowledge base.

A large proportion of the papers, covering both the selection and technical aspects of the more unconventional roofing types and case studies thereof, were written by the expert whilst employed by the CSIR. During this period he was involved in case studies of housing projects in which these alternative roofing types were used. Today, he is an employee of the Development Bank of South Africa. One of the projects in which he is currently involved, is the setting up of the TACs at the sites of IDT projects, as was discussed in chapter 2.

The expert therefore provided invaluable assistance in the form of both an expert in the selection process as well as being representative of a potential end-user.

4.3.1 ANALYSIS OF BUILDROOF STRUCTURE

With regards to the expert the debriefing goals were:

* to verify the importance of each sub-domain as identified from the literature survey and in addition to identify other sub-domains that may not have been covered or identified

in the literature survey;

* to develop an outline of these sub-domains by placing them in some form of a hierarchy and
* to identify which chunks of knowledge the experts draw upon for each of these sub-domains and what the individual logical reasoning processes are.

The first two points will be covered in this chapter. The final point will be discussed in chapter 5.

(a) Verification of sub-domains

The sub domains as outlined from the literature survey were verified by the expert. Additional sub-domain were identified:

(i) Acceptability of a roofing type to an end-user

In order to query this of the end-user, it was decided that a visual guide containing photographs and sketches of the roof types would be supplied. (See Appendix C for BUILDROOF VISUAL GUIDE)

(ii) Suitability of the roofing type to the walling material used

It was decided that roofing could not be considered totally independently of the rest of the housing structure. However, at the same time, due to time constraints, as well as bearing in mind that the objective of this project was not to develop an expert system for the whole house, but only for selecting the roofing system, it was decided that

only the walls would be considered and then only very briefly.

With respect to walling, roofing types can be categorised into one of two types:

* self standing i.e. non load-bearing walls
* non self standing i.e. non load-bearing walls

Common walling materials are:

* bricks i.e load bearing
* concrete i.e. load bearing
* zinc, plastic, wood etc. i.e non load-bearing

(iii) Suitability of the roofing type to the walling span

A common characteristic of alternative roofing types is a restriction in the allowable span. Typically, a range of fixed spans or a limited maximum span are available.

(b) Developing a hierarchical outline of these sub-domains

The sub-domains identified for selecting a suitable roofing type were placed in the hierarchy as shown in figure 4.1. The following factors contributed towards this final hierarchy:

(i) In order to eliminate unwanted or unsuitable roofing types as quickly and soon as possible, those sub-domains that were relatively end-user

independent and that required minimal input from the end-user, were given priority. These were identified as being the processes of checking each roofing type for climatic suitability, ability to meet extras as identified by the end-user and approximate affordability.

(ii) In order to prevent instilling potentially unrealistic expectations in the end-user, it was decided that the acceptability of a roofing type to an end-user should only be queried once it has been found that:

* it is climatically suitable;
* it meets the extras required by end-user;
* it is vaguely affordable and
* it's required goods and services (i.e. modules, equipment, materials, tools and labour) are available;

For this reason, this data is all queried and checked prior to the actual querying of acceptability to the end-user.

(iii) Within the sub-domain checking for availability of goods and services, the final checking order was:

modules
equipment
materials
tools and labour.

Factors contributing towards this order were:

* Modules include building blocks in the case of units and elements in the case of systems.

Since the modules form the core of the roofing types, their availability was critical for further analysis to be warranted. In addition, in the case of the systems, depending on whether elements are to be purchased or self-built (this is determined when checking for availability of modules), different goods and services are required. Therefore modules availability needed to be determined prior to checking for availability of the remaining goods and services i.e. at the outset.

* Equipment largely incorporates additional equipment required if systems are to be self-built. This check was therefore placed directly after modules checking.
* Due to the nature of the roofing types incorporated (i.e. units and systems), skills required for the roofing types were largely relatively unskilled. Since unskilled labour is found in abundance in South Africa, shortages thereof were not anticipated. Therefore skills were the last to be considered.
* The tools required were found to be relatively standard. Materials however appeared to be potentially location dependant and thus more critical. Therefore the checking of material and tools availability were placed third and fourth respectively.

(iv) Final and detailed costing should only progress once the roofing type had met the criteria discussed above as well as been accepted by the end-user.

By considering these points the final layout of the sub-domains considered when selecting roofing types, was compiled. (See fig 4.1)

4.3.2 ADDITIONAL REQUIREMENTS OF EXPERT SYSTEM AS IDENTIFIED BY EXPERT AND POTENTIAL END-USERS

The development process does not necessarily end when an expert system goes into everyday use. While the system may be useful for an extended period of time, it may also become dated in that knowledge may change or become incomplete.[6]

BUILDROOF is not an exception in that the following are dynamic:

* with new roofing types being developed and marketed, the database of roofing types may become incomplete;
* the availability and costs of modules, equipment, materials, tools and skills may change and/or become incomp. te and
* the draft costs of roofing types may change.

From discussions held with the IDT (represented by Mr Arrigone) and ABA, and from observations above, it was decided that a system solely selecting a roofing type would not be sufficient and

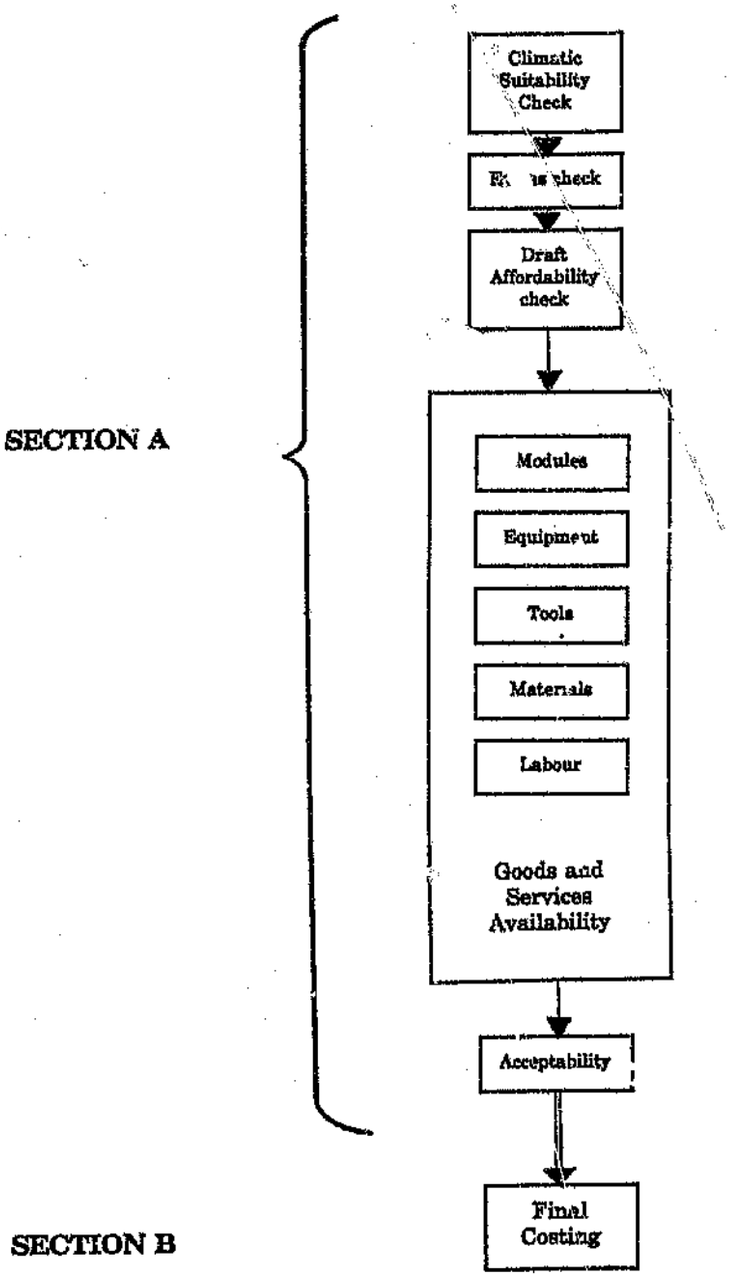


Figure 4.1 Hierarchy of sub-domains for selecting roofing types

realistic to the dynamic environment in which it was to be adopted.

The following facilities were therefore added:

* the ability to enter a new roofing type into the database without the assistance of the programmer;
* the ability to store and update information on the availability of modules, equipment, materials, tools and skills and
* the ability to update draft costs by manipulating actual roofing costs returned back into the system.

The final structure of the BUILDROOF expert system was therefore as shown in figure 4.2.

4.4 UTILISATION OF EXSYSPRO SHELL FACILITIES FOR MEETING REQUIREMENTS

If BUILDROOF had only needed to incorporate the four roofing types that it was supplied with for the purpose of this project and the data pertaining to them had been of a static nature, then these roofing types could have been defined as the choices and a set of rules incorporating data on each of these roofing types could have been used. However, since requirements as outlined in section 4.3 specified that BUILDROOF should be independent of the programmer in accommodating new roofing types and storing or updating data, the knowledge base had to be structured to allow

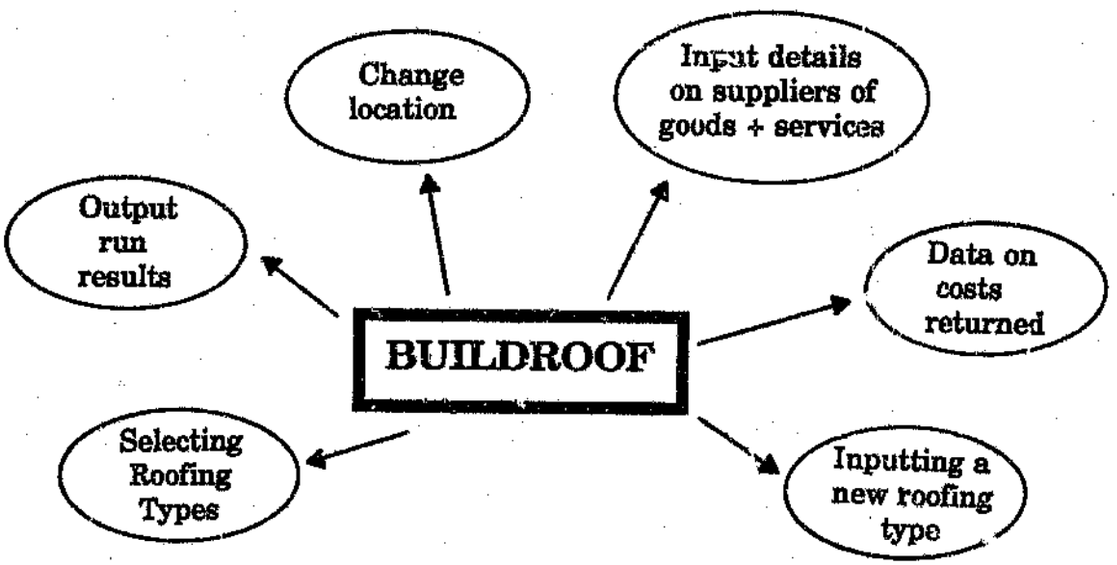


Figure 4.2 BUILDROOF package

for this. This was achieved by making the rules independent of any specific roofing type i.e. setting up rules that applied to systems and units in general and not a specific system or unit. The actual data was stored in frames and replaced by variables in the rules. Thus values corresponding to these variables, if and when required, could be retrieved from the frames introduced for storing data. Updating actual data could be achieved by simply replacing these frame values. In addition, data on new roofing types could be entered into reserved empty spaces in the frames in order to be eligible for analysis.

These rules could therefore be used for selecting any one of the roofing types already included in BUILDROOF. They could also be used for analysing any new unit or system roofing type introduced on condition that it's hard core data had been entered into the data frames.

These methods adopted will be discussed further in chapter 5 under the various sub-domains and section headings.

5. STRUCTURE OF BUILDROOF

From the sub-domains and requirements identified and the final BUILDROOF structure as outlined in chapter 4, the following options were included in the BUILDROOF Menu:

1. Run BUILDROOF i.e. selecting a roofing type
2. Output BUILDROOF run results
3. Change location
4. Input of data on availability of modules, equipment, materials, tools and labour
5. Data on costs returned
6. Inputting a new roofing ty,

Each of these will be discussed further with regards to the reasoning processes and the use of variables, qualifiers and frames.

In addition, problem areas identified during the development of BUILDROOF are discussed.

5.1 RUN BUILDROOF

This constitutes the body of the BUILDROOF software package. Running of BUILDROOF is the option which end-users, wanting information on roofing types that meet their requirements as well as constraints, will run.

The running of this option can be sub-divided into two major sections, selection and costing, as depicted in figure 5.1.

The first section, Section A, consists of a selection process in which roofing types not meeting the selection sub-domain criteria as shown in figure 5.1, are eliminated.

The second section, section B, consists of relatively detailed costing of those roofing types that passed through the selection process.

Each of these two sections will be discussed individually.

5.1.1 SECTION A OF RUNNING BUILDROOF

Since the rules in the knowledge base are universal in that they apply to any one of the roofing types included (as opposed to a set of rules for each roofing type), a mechanism had to be introduced whereby the performance of each roofing type in the various sub-domain checks, could be recorded. This was achieved using a frame as shown in figure 5.2. This frame was used in the following fashion:

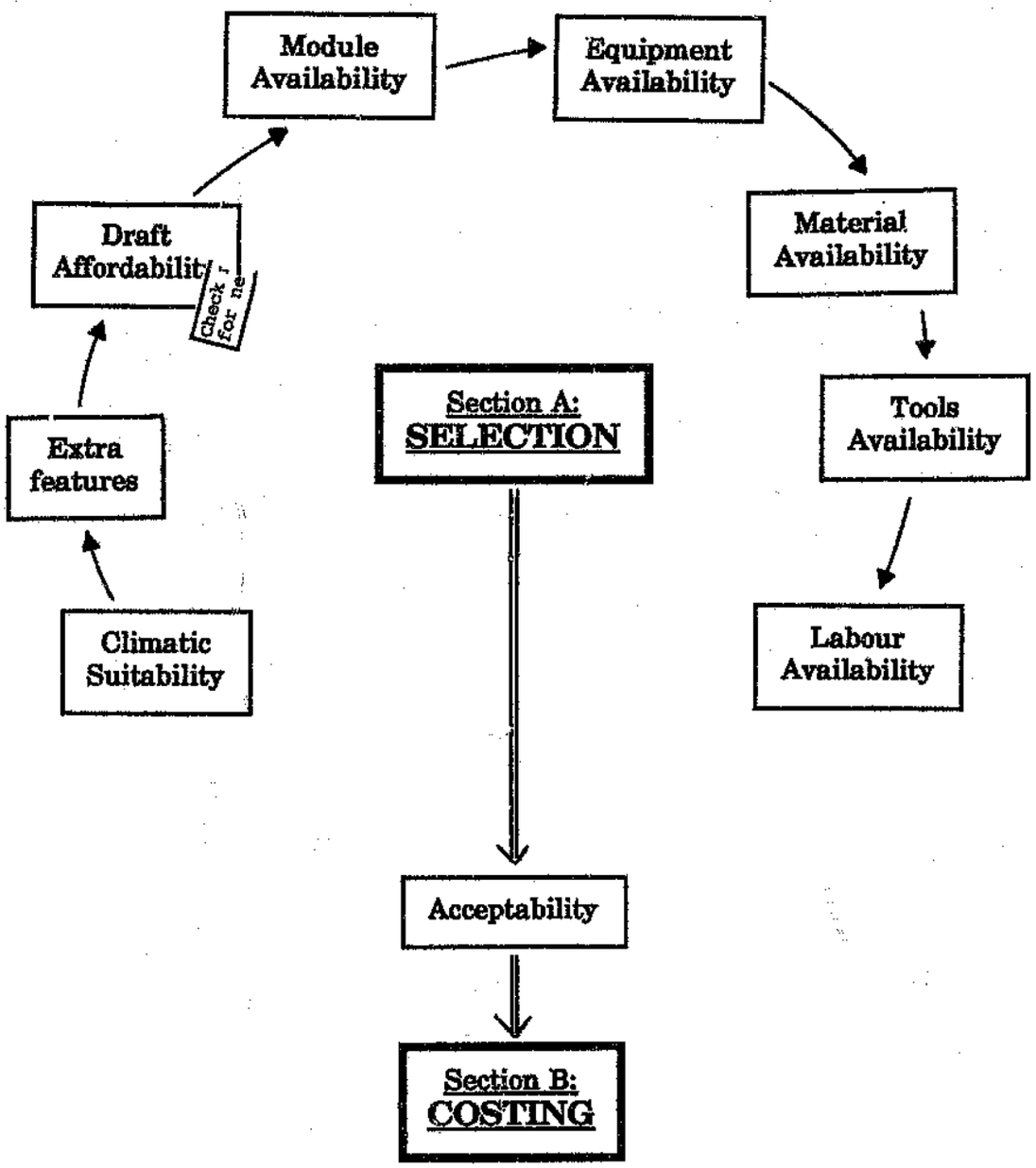


Figure 5.1 'Running of BUILDROOF' structure

A number greater than zero was allocated in the 'CLIM' column of all those roofing types passing the first sub-domain check i.e. climatic suitability. Only these roofing types were then eligible for investigating with regards to the second sub-domain check i.e. extras. This process was repeated for the all the remaining sub-domains of section A.

RS	NAME	TYPE	CLIM	EXTRAS	FIN	MODS	EQUIP	MATS	TOOLS	LABOUR	ACCEPT
1	Evertile Fast-Frame Unit	Unit	0	0	0	0	0	0	0	0	0
2	USSR	Unit	0	0	0	0	0	0	0	0	0
3	Concrete precast troughs	Sys	0	0	0	0	0	0	0	0	0
4	Concrete hollow blocks	Sys	0	0	0	0	0	0	0	0	0
5	new	new	0	0	0	0	0	0	0	0	0
6	new	new	0	0	0	0	0	0	0	0	0
7	new	new	0	0	0	0	0	0	0	0	0
8	new	new	0	0	0	0	0	0	0	0	0
9	new	new	0	0	0	0	0	0	0	0	0
10	new	new	0	0	0	0	0	0	0	0	0

Figure 5.2 Section A frame

(a) Climatic Suitability

One of the requirements of BUILDROOF was that it should be suited to cosmopolitan application. This means that every time the location of the end-user changes, the climatic suitability of the roofing types in the database to the new region need to be reassessed (i.e column 'CLIM' of the section A frame). In addition, any new roofing type introduced to the database also needs to be checked for it's climatic suitability to the current location.

On completion of programming of BUILDROOF, Bloemhof-Transvaal was selected as the location of the end-user's home. In steps as are discussed in section 5.3 and 5.6, the suitability of the roofing types in the database to the climatic region into which Bloemhof falls, were assessed and stored in the 'CLIM' column of the Section A frame.

For every subsequent run of BUILDROOF thereafter, one of the two following events would take place:

* If the location remains the same and no extra roofing types have been added since the previous run, the climatic suitability of all the roofing types should remain static i.e. the 'CLIM' column of the section A frame will not change. Therefore the rules applying to the climatic suitability sub-domain will not be fired, thus avoiding unnecessary time loss.

* If however the end-user has changed the location or if a new roofing type has been added to the database in the interim, then on running BUILDROOF again, the climatic suitability sub-domain rules required to recheck the full range of roofing types in the database will be fired. The reassessed suitability of each roofing type will replace the previous values in the climatic suitability frame as shown in figure 5.3. These climatically suitable roofing types (i.e. 'Yes' in the 'VALUE' column of the climatic suitability frame) are then allocated a number in the 'CLIM' column of the Section A frame, thus potentially

changing this column. This column will now remain as is until either a different location is again chosen or a new roofing type introduced.

In this way, those roofing types to be investigated in the next selection sub-domain (i.e. extras) will be indicated in the 'CLIM' column of the section A frame.

DATA	NAME	NO	VALUE
Province/Homeland	o	0	Transvaal
City/Town	o	0	Bloemhof
Region	o	0	Sn
o	Evertile Fast-Frame Unit	1	Yes
o	USSR	2	Yes
o	Concrete precast troughs	3	Yes
o	Concrete hollow blocks	4	Yes
o	new	5	new
o	new	6	new
o	new	7	new
o	new	8	new
o	new	9	new
o	new	10	new

Figure 5.3 Climatic suitability frame

(b) Extra features wanted by end-user

A frame, as shown in figure 5.4, was created to store each roofing type's details on the extras. The methodology used in storing this data will be discussed with regards to each feature.

RS	NAME	PITCH			CEILING		WALLS			TEMP	CORE	COAST	GUTTER		WALLS_BUILT	
		MONO	DBL	OTHER	FAC	INCL	CONC	BRICKS	OTHER				FAC	INCL	SUIT	SPAN
1	Evertile Fast Frame Unit	No	Yes	No	Yes	No	Yes	Yes	Yes	Yes	Yes	No	No	No	Yes	7.78
2	USER	Yes	Yes	No	No	Yes	Yes	Yes	Yes	Yes	Yes	No	Yes	Yes	Yes	7.20
3	Concrete precast troughs	Yes	No	No	No	No	Yes	Yes	No	No	Yes	Yes	Yes	No	[illegible]	3.5
4	Concrete hollow blocks	Yes	No	No	No	No	Yes	Yes	No	No	Yes	Yes	Yes	No	new	3.26
5	new	new	new	new	new	new	new	new	new	new	new	new	new	new	new	0
6	new	new	new	new	new	new	new	new	new	new	new	new	new	new	new	0
7	new	new	new	new	new	new	new	new	new	new	new	new	new	new	new	0
8	new	new	new	new	new	new	new	new	new	new	new	new	new	new	new	0
9	new	new	new	new	new	new	new	new	new	new	new	new	new	new	new	0
10	new	new	new	new	new	new	new	new	new	new	new	new	new	new	new	0

Figure 5.4 Extras frame

The reasoning process is outlined in figure 5.5. The qualifiers and their values used are documented in table 5.1.

The end-user is first asked whether or not the walls have been built. Depending on the answer entered, they are then asked to enter details on spans. If the walls have already been built then the end-user is asked to enter the width. If the walls have not yet been built, then the width wanted is queried. In order to guide the end-user, the largest allowable span of all the roofing types in the database is presented on the screen as a guideline. The value entered by the end-user is then checked against the 'maximum allowable span' as stored in the 'span' column of the extras frame for each roofing type. If this is suitable, then the

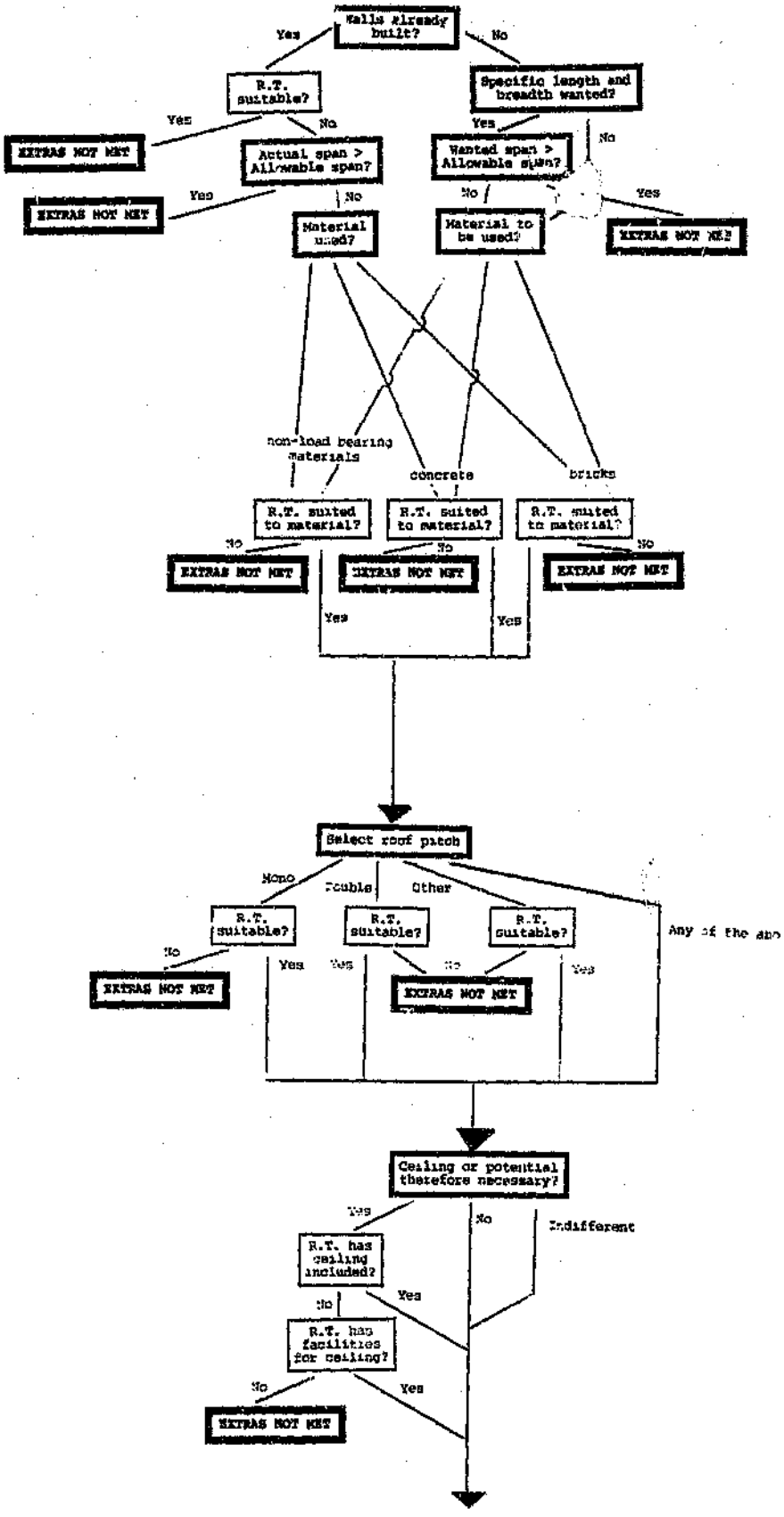


Figure 5.5 Extras reasoning process

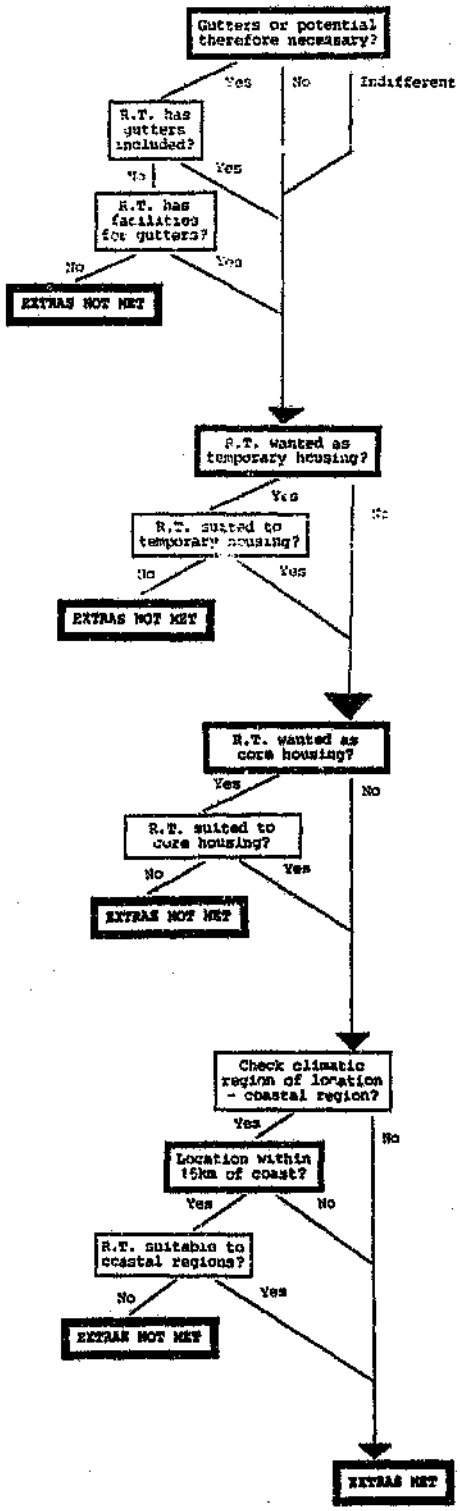


Figure 5.5 Extras reasoning process continued

FEATURE	QUALIFIER	VALUES
Suitability to extensions (core-housing)	Must the roofing type be suited for EXTENSIONS at a later stage?	1. Yes 2. No 3. Indifferent
Suitability to temporary housing	Is the roofing type wanted as TEMPORARY HOUSING?	1. Yes 2. No 3. Indifferent
Inclusion or facilities for ceilings	Is a CEILING or potential therefore necessary?	1. Yes 2. No 3. Indifferent
Inclusion or facilities for gutters	Are GUTTERS or potential therefore necessary?	1. Yes 2. No 3. Indifferent
Slope of roof	Which PITCH would you like for your roofing type?	1. Mono pitch 2. Double pitch 3. Other 4. Any of the above
Suitability to walling material	Have your WALLS already been built?	1. Yes 2. No
	What WALLING MATERIAL are you planning to use?	1. Concrete blocks 2. Bricks 3. Sheeting, cardboard etc.
	What WALLING MATERIAL has been used?	Same as above
Suitability to coastal regions	Is the site of your home...	1. further than 15km from the coast 2. closer than 15km from the coast

Table 5.1 Qualifiers and values used for EXTRAS check

end-user is asked to indicate which of the walling materials were or are to be used. The answer entered is then checked against the suitability as stored in the extras frame.

The pitch type selected by the end-user is checked against each roofing type's suitability to it.

Only if affirmative responses are entered for ceiling and gutters extras, will each roofing type be checked.

The end-user is asked directly as to whether they want a roofing type which is suited to temporary housing. Only if a positive response is entered, will the rules checking for the suitability of each roofing type to this requirement, be fired.
The check for suitability to extensions is similar to this.

Of the 12 regions that South Africa is divided into for climatic analysis, 5 incorporate stretches along the coast. If the region, as stored in the climatic suitability frame, is one of the 5 coastal regions then the end-user will be asked to enter their distance from the coast. Only if the distance entered is critical (i.e. if the location is less than 15 kilometres from the coast), will the rules checking each roofing type's suitability to coastal areas be fired and those found not to be suited, as shown in the extras frame, be eliminated.

Roofing types meeting the features required as defined by the end-user, are allocated a number in the extras column of the SECTION A frame and are therefore eligible to be

investigated further in the next selection sub-domain i.e. draft costing.

(c) Draft costing test

In order to avoid investigating a roofing type fully only to discover at the end that it is unaffordable to the end-user, it was decided to check the approximate affordability of a roofing type at this point.

Due to different end-user scenarios it was decided that the roofing type costs, against which affordability is to be measured, should be estimated for a few of these scenarios.

In the case of Units, three costs were calculated for each sub-unit (design or shape). Since end-user costs are dependant on who the sub-unit is erected by, the draft costs were calculated as a function of three potential end-user statuses i.e. self-builders, artisans and small scale contractors. (See Appendix A1 and A2).

It was felt that the main factor contributing to the difference in costs of systems will be whether the systems are being purchased or self-built. Therefore these two scenarios were considered and costed for. (See Appendix A3 and A4).

These initial approximate costs were obtained from the expert in each roofing type. In case of units, the contractors costs were approximated to be the lowest. Reasons given for this assumption were their improved access to goods, materials and technical expertise. In addition their improved position when negotiating prices

due to the larger quantities in which they employ these goods, materials and skills.

Experts approximated that purchasing the systems elements as apposed to self-building would translate into a roughly 20% markup.

Due to their very nature, the manner in which this draft affordability check is handled, differs for units and systems: Only the first sub-unit of each Unit's roofing type, as built by a contractor, is checked for affordability. Contractors predicted costs were the lowest and since the sub-units were entered in increasing sizes, it will be the smallest and therefore the cheapest. Therefore, if this one passes there is a chance that others may too, whereas if it fails, so will all others. This is illustrated in figure 5.6.

The units frame, as shown in figure 5.7, contains the approximate cost details of the sub-units.

In the case of systems, affordability is measured by the number of elements and thus the area that can be afforded. The cost per element is taken as the cheapest of the two costs i.e. the self-building cost. This area is proposed to the end-user and the end-user is given the option of either rejecting or accepting the proposal as shown in figure 5.6. Due to EXSYSPro's inability to truncate or round off a variable's value, the values of these areas are more often than not represented as having many decimal places. This is both inappropriate and unnecessary.

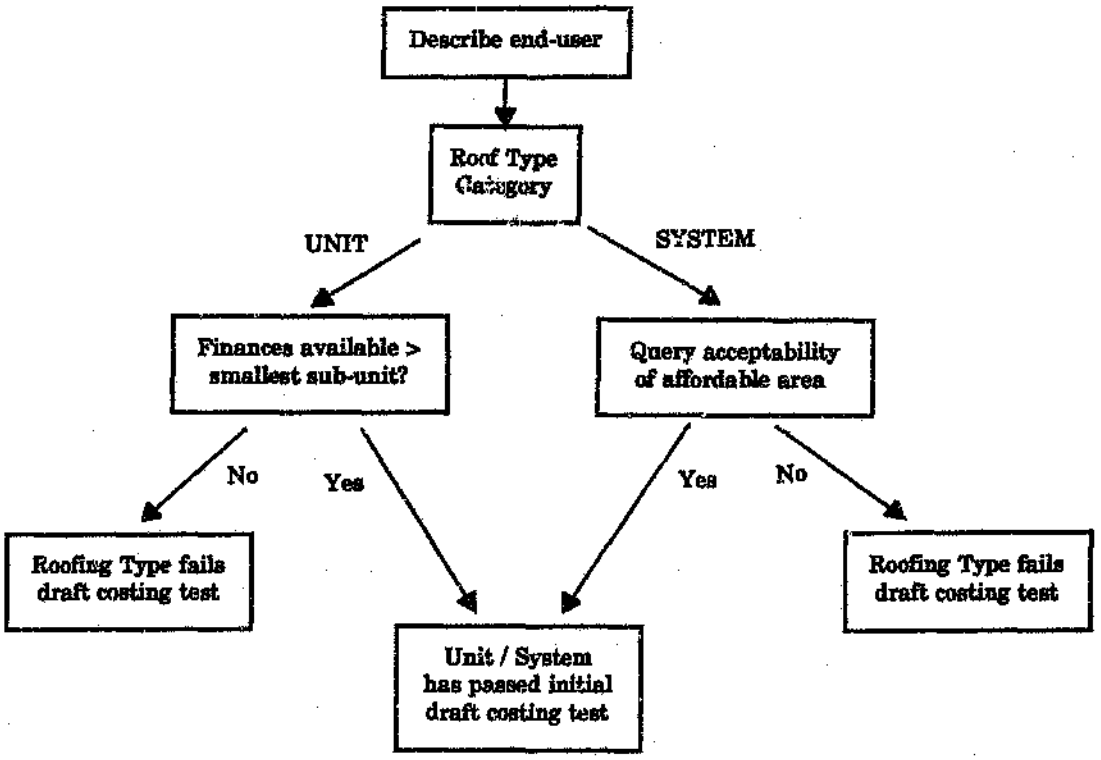


Figure 5.6 Draft costing reasoning process

RS	UNIT	UNIT_NAME	NO	UNIT_NO	UNIT_TYPE	AREA	UN	COST		
								SELF	ART	CONT
1	1	Evertile Fast-Frame Unit	1	1	EFU T40	40	m2	9695	9480	9270
1	1	Evertile Fast-Frame Unit	2	2	EFU T50	50	m2	10985	10750	10510
1	1	Evertile Fast-Frame Unit	3	3	EFU T40+T15	55	m2	12725	12450	12175
1	1	Evertile Fast-Frame Unit	4	4	EFU T60	60	m2	12290	12025	11755
1	1	Evertile Fast-Frame Unit	5	5	EFU T50+T15	65	m2	14020	13715	13410
1	1	Evertile Fast-Frame Unit	6	6	EFU T70	70	m2	13635	13340	13045
1	1	Evertile Fast-Frame Unit	7	7	EFU T40+2*T15	70	m2	15760	15420	15075
1	1	Evertile Fast-Frame Unit	8	8	EFU T60+T15	75	m2	15325	14990	14660
1	1	Evertile Fast-Frame Unit	9	9	EFU T50+2*T15	80	m2	17055	16685	16315
1	1	Evertile Fast-Frame Unit	10	10	EFU T70+T15	85	m2	16670	16310	15945
1	1	Evertile Fast-Frame Unit	11	11	EFU T60+2*T15	90	m2	18360	17960	17560
1	1	Evertile Fast-Frame Unit	12	12	EFU T70+2*T15	100	m2	19705	19275	18850

Figure 5.7 EFU Units frame

Figure 5.8 shows the systems' frame containing the two costs of each element.

RS	SYS	SYS_NAME	AREA	UM	COST	
					SELF	PURCH
3	1	Concrete precast troughs	1.225	m2	40.70	48.80
4	2	Concrete hollow blocks	0.815	m2	55.58	66.70
0	3	new	0	m2	0	0
0	4	new	0	m2	0	0
0	5	new	0	m2	0	0
0	6	new	0	m2	0	0

Figure 5.8 Systems frame

The first approximate costs (as stored in the units and systems frames) are subject to error depending on assumptions undertaken by the expert in costing the roofing type. In attempting to compensate for this, two steps were taken:

* A variability factor of 10% was applied to affordability (i.e. roofing types which cost up to 10% higher than the end-user's finance available, will still pass this stage).
* BUILDROOF has a facility which enables end-users who have run BUILDROOF, obtained predicted costs and then actually built it, to input the actual costs versus predicted costs. In this way the values used in the first affordability test can be gradually

updated to be more representative of actual costs. (See section 5.5 (i))

Those roofing types that have passed all the previous stages are thus checked for approximate affordability in either of the two methods discussed above, depending on whether they are of type systems or units.

(d) Availability of goods and services

In the following five sub-domains, the availability of the following goods and services required for each roofing type is queried of the end-user:

* modules
* equipment
* materials
* tools and
* labour

The methodology used in querying this information will be discussed.

The availability (unlike the detailed costing of required goods and services which follows in section B) is not asked in a very detailed form, since the only object of asking this data at this stage is to find out whether the services and goods, required for the roofing types that have been channelled down, are actually available, and therefore whether it is worthwhile investigating a particular roofing type further or not.

It was decided to keep records of any available suppliers of goods or services. A 'supplier' frame as shown in figure 5.9 was created to store data on the supplier availability and 'Information frames' were created to store the particulars of suppliers where they are available. (See section 5.4 for more details).

'Goods and services required' frames, as shown for tools required for units in figure 5.10, were created to store data on which goods and services are required for each roofing type.

(i) 'Supplier' frame

The supplier frame, as shown in figure 5.9, keeps track of the following information for each goods or service:

<> '*_NAME' column for the goods or service name e.g. TL_NAME for tool names;

<> '*_SUP' column to keep track of whether details of any suppliers are available in the 'information' frames. A '1' indicates that details on at least one supplier are available in the corresponding information frame while a '0' indicates that no suppliers are available.

<> '*_NEW' column with two sub columns i.e. 'Y' and 'N' are used to store newly acquired, end-user specific information on availability, obtained from the current end-user. A '1' in either of these columns indicates that the end-user has already been queried as to the availability of particular goods or services and has answered as indicated.

Data will only be asked (for the purposes of storing in these sub-columns) if the '*_SUP' column is equal to zero i.e. if no details are yet available on suppliers.

NO	TOOLS			LABOUR			MATERIALS				
	TL_NAME	TL_SUP	TL_NEW	LAB_NAME	LAB_SUP	LAB_NEW	MAT_NAME	UNIT	MAT_SUP	MAT_NEW	
			Y N			Y N				Y N	
1	EFU Lifing Jack	0	0 0	Unskilled	1	0 0	Water	litres	1	0 0	
2	Spade	1	0 0	Skilled	1	0 0	Cement	t	1	0 0	
3	Hammer	1	0 0	new	0	0 0	Sand	m3	0	0 0	
4	Shifting Spanner	0	0 0	new	0	0 0	Reinforcing bars-4mm	m	1	0 0	
5	Drilling machine	0	0 0	new	0	0 0	Reinforcing bars-3.3mm	m	1	0 0	
6	Pop Riveter	0	0 0	new	0	0 0	Gravel (18-22mm)	m3	0	0 0	
7	Wheelbarrow	1	0 0	new	0	0 0	Polyethylene sheeting	m2	1	0 0	
8	Trowel	0	0 0	new	0	0 0	Bitumen	cm3	1	0 0	
9	Level	0	0 0	new	0	0 0	Reinforcing bars-6mm	m	1	0 0	
10	new	0	0 0	new	0	0 0	Reinforcing bars-4.5mm	m	1	0 0	
11	new	0	0 0	new	0	0 0	Weld mesh reinf to.076	m2	0	0 0	
12	new	0	0 0	new	0	0 0	Stone 2-15mm)	m3	0	0 0	
13	new	0	0 0	new	0	0 0	Thin polyester fibre matt	m2	0	0 0	
14	new	0	0 0	new	0	0 0	Paint	litres	0	0 0	
15	new	0	0 0	new	0	0 0	new	0	0	0 0	

Figure 5.9 Supplier frame showing details for tools, labour and materials only

Note: Since columns pertaining to the last point above are end-user specific, they are cleared at the end of each BUILDROOF run.

(ii) 'Goods and services required' frames

Requirements of each goods or service required for each sub-unit and system is stored. Units and systems are dealt with separately.

In the case of systems, different values apply depending on whether the system's elements are to be self-built (S) or purchased (B).

Table 5.2 indicates the data stored for each goods or service.

GOODS OR SERVICE	TIME REQD		NO. REQD	QUANTITY REQD (Volume, mass etc.)
	Days	Hours		
Modules			x	
Equipment	x	x	x	
Materials				x
Tools	x	x		
Labour	x	x		

Table 5.2 Data stored in 'goods and services required' frames

Figure 5.10 is a frame of tools required for units. Tools are represented by numbers (as apposed to their actual name) since frame heading rows cannot be accessed from an EXSYSP run. The actual name

is stored in the supplier frame corresponding to the tool number (See figure 5.9). This makes it possible for a new tool name to be entered (if necessary) with a new roofing type.

H, D and N refer to hours, days and numbers of tools required respectively. This corresponds to table 5.2 details.

The method whereby these values are calculated is discussed in section 5.6.2.

RS	UNIT	UNIT_NAME	NO	UNIT_NO	UNIT_TYPE	TOOLS																	
						1			2			3			4			5			6			
						H	D	N	H	D	N	H	D	N	H	D	N	H	D	N	H	D	N
1	1	Evertile Fast-Frame Unit	1	1	EFU T40	2.5	.31	2	8	1	1	2.5	.31	1	2.5	.31	2	2.5	.31	2	2.5	.31	2
1	1	Evertile Fast-Frame Unit	2	2	EFU T50	2.5	.31	2	8	1	1	2.5	.31	2	2.5	.31	2	2.5	.31	2	2.5	.31	2
1	1	Evertile Fast-Frame Unit	3	3	EFU T40+T15	5.0	.63	2	12	1.5	1	5.0	.63	2	5.0	.63	2	5.0	.63	2	5.0	.63	2
1	1	Evertile Fast-Frame Unit	4	4	EFU T60	2.5	.31	2	8	1	1	2.5	.31	2	2.5	.31	2	2.5	.31	2	2.5	.31	2
1	1	Evertile Fast-Frame Unit	5	5	EFU T50+T15	5.0	.63	2	12	1.5	1	5.0	.63	2	5.0	.63	2	5.0	.63	2	5.0	.63	2
1	1	Evertile Fast-Frame Unit	6	6	EFU T70	2.5	.31	2	8	1	1	2.5	.31	2	2.5	.31	2	2.5	.31	2	2.5	.31	2
1	1	Evertile Fast-Frame Unit	7	7	EFU T40+2*T15	7.5	.94	2	16	2	1	7.5	.94	2	7.5	.94	2	7.5	.94	2	7.5	.94	2
1	1	Evertile Fast-Frame Unit	8	8	EFU T60+T15	5.0	.63	2	12	1.5	1	5.0	.63	2	5.0	.63	2	5.0	.63	2	5.0	.63	2
1	1	Evertile Fast-Frame Unit	9	9	EFU T50+2*T15	7.5	.94	2	16	2	1	7.5	.94	2	7.5	.94	2	7.5	.94	2	7.5	.94	2
1	1	Evertile Fast-Frame Unit	10	10	EFU T70+T15	5.0	.63	2	12	1.5	1	5.0	.63	2	5.0	.63	2	5.0	.63	2	5.0	.63	2
1	1	Evertile Fast-Frame Unit	11	11	EFU T60+2*T15	7.5	.94	2	16	2	1	7.5	.94	2	7.5	.94	2	7.5	.94	2	7.5	.94	2
1	1	Evertile Fast-Frame Unit	12	12	EFU T70+2*T15	7.5	.94	2	16	2	1	7.5	.94	2	7.5	.94	2	7.5	.94	2	7.5	.94	2
2	2	USER	13	1	USER 15	0	0	0	8	1	1	4	1.5	2	0	0	0	0	0	0	0	0	0
2	2	USER	14	2	USER 30	0	0	0	12	1.5	1	8	1	2	0	0	0	0	0	0	0	0	0
2	2	USER	15	3	USER 45	0	0	0	16	2	1	12	1.5	2	0	0	0	0	0	0	0	0	0
2	2	USER	16	4	USER 60	0	0	0	16	2.3	1	16	2	2	0	0	0	0	0	0	0	0	0
0	0	new	17	0	new	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	new	18	0	new	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	new	19	0	new	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	new	20	0	new	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Figure 5.10 'Tools required for units' frame

In order to clarify the process, an explanation of the reasoning process is documented. Figure 5.11 represents a graphical representation thereof.

(1) Availability of Tools

Tool availability for the first roofing type having passed the previous sub-domain's check i.e. draft costing will be investigated first. Depending on whether it is a system or a unit, it will investigate either the SY_TOOLS tools required frame (systems) or UN_TOOLS tools required frame (units).

In the case of systems the end-user will have selected one of two options within the availability of modules sub-domain (which is discussed in (b)) i.e. self-building versus buying. Different goods and services are required depending on the choice made here. The rules then check each tool as to whether they are required by checking the number of hours they are required from the relevant goods frame i.e. column '1S.H' in the SY_TOOLS frame denotes the number of hours that tool #1 is required if self-building the system. If the number is zero, then the tool is not required and therefore the next tool is checked. However, if the value is greater than zero then the tool is required. Since the only object of this section is the querying of availability, the program first checks whether a supplier is available by checking the 'TL_SUP' column of the supplier frame. If the figure in this column is 1, then details of at least one supplier are available from the information frames and so the next tool is checked.

(This does not however restrict the end-user to making use of these suppliers whose details are stored when entering data for detailed costing in Section B. It merely prevents querying the end-user when details on a supplier are already known).

If a zero appears in this column i.e. no information on a supplier is available in the information frames then the 'TL_NEW' column, which is used to store end-user specific data on availability, is checked. Three potential scenarios exist:

* The tool was required for a previous roofing type and the end-user has already answered positively to availability of this tool. In this case a '1' will be stored in the 'Y' sub-column. This will thus prevent querying the end-user again since the end-user has already indicated that he/she has access to such a tool. The rules fired for checking on availability of tools will therefore be cleared. The variables are replaced with the details of the next tool required for the current roofing type, so as to check it next. This process is repeated until all tools have been checked.

* The tool was required for a previous roofing type and the end-user has already answered negatively to availability of this tool. In this

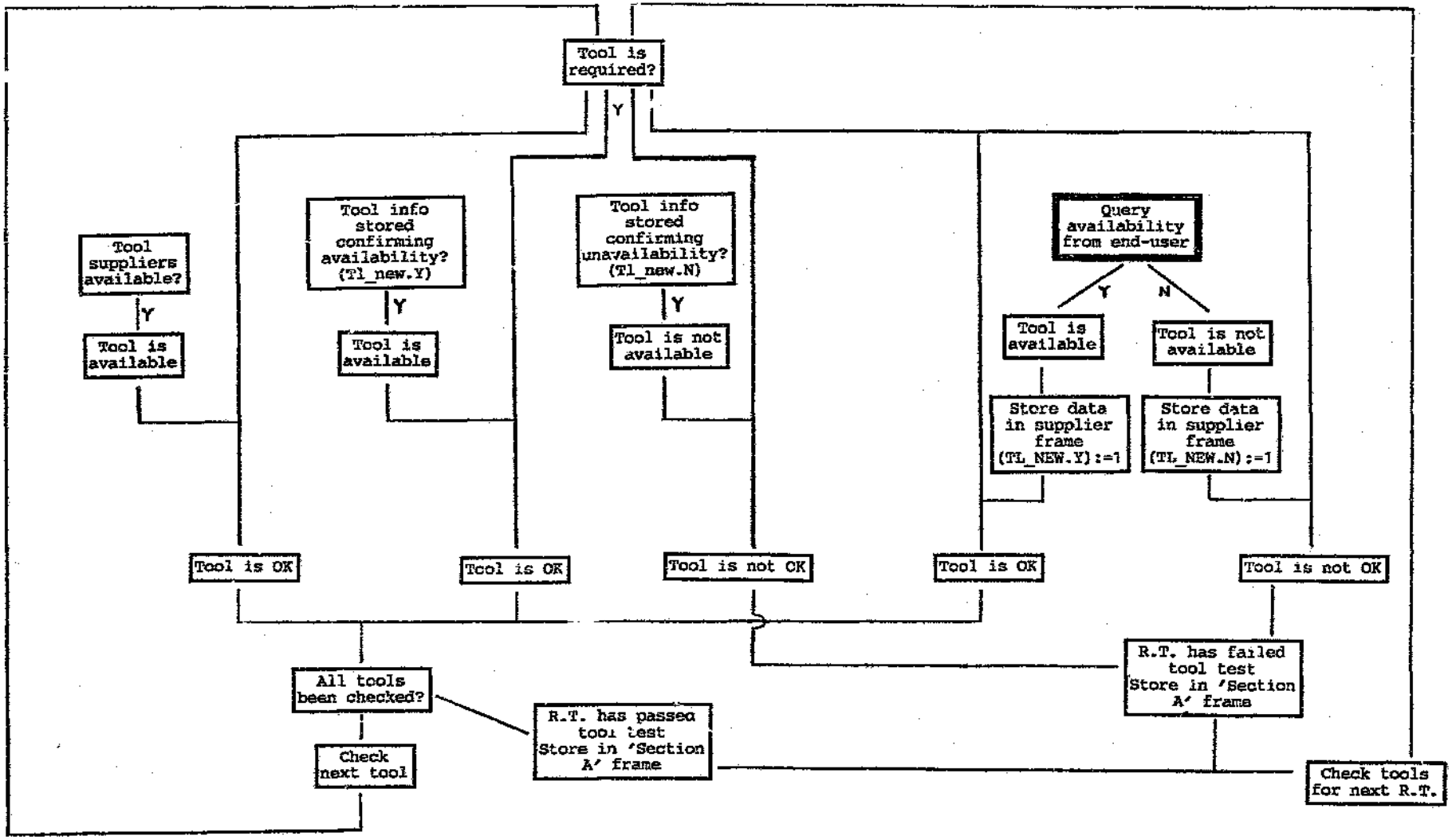


Figure 5.11 Graphical representation of tools availability reasoning process

case a '1' will have been stored in the 'N' sub-column. The current roofing type will thus automatically fail it's tool test and therefore will not be elligible for further investigation. A zero will be stored in the TOOLS column of the SECTION A frame indicating that this roofing type is not elligible for further investigation. The investigation will move onto the testing for availability of the tools of the next roofing type.

* The end-user has not yet been asked as to availability of the tool in which case both sub-columns will contain zero's. In this case, the end-user will be directly queried as to availability of the tool using a qualifier with only two values e.g.

Is/Are hammers available to you?
1. Yes
2. No

Depending on the value entered, any one of the two paths as just outlined in (1) and (2) will be followed.

Only once all the tools for all the roofing types that were channeled down for further investigating have been analysed, will the next goods or service be analysed. This decision was taken so as to prevent jumping around from one good or service to another only to return everytime a new roofing type is analysed.

(2) Availability of modules

In the case of checking for the availabilty of modules, a slightly different approach is taken: Since only one module type is required per roofing type and since the roofing types are numbered, the module type required for each roofing type was allocated the roofing type's number. The rules checking each roofing type for module availability were thus structured to only check the column of the 'modules required frame' corresponding to the number of the roofing type. This eliminated the unnecessary process of checking all the module columns as was necessary for tools. Figure 5.12 depicts the reasoning process adopted for the module checking sub-domain.In the case of UNITS, for the purposes of this sub-domain check, only the availability of the module type (building blocks type) required for each unit is checked - NOT individual building blocks e.g. USSR building blocks as apposed to a specific building block e.g. the

USSR15 building block. The assumption was made that if the units were available, then all the individual building blocks corresponding to that unit would be available.In the case of SYSTEMS, the availability of suppliers of elements is checked from the supplier frame. If a supplier exists, then rules will be fired so as to move onto the modules check of the next roofing type. If no supplier of the building blocks exists, then the end-user is queried as to whether they are interested in investigating the possibility of constructing the building blocks themselves. Depending on the reply, the system will either be investigated further or scrapped. In the case where the system is to be investigated further, the choice which was made (i.e self construction vs. purchasing) is stored in the 'modules required for systems frame' i.e. 'S' for self-build and 'B' for purchase. This is important since the equipment, materials, tools and labour on which the end-user is to be queried in the following stages, will obviously be dependent on this choice.

This is the reason why the availability of modules is the first to be checked and equipment (goods required if system's elements are self-built but excluding materials, tools and skills) the second.

Although draft costs of 'purchased' and 'self-built' elements are stored in the systems frame (fig 5.8), for the draft affordability check (see section

5.1.1(iii)), the assumption was made that the end-user was self building the elements. This was the cheapest and therefore the most lenient assumption to make at this point. However, by now the choice of how the elements are to be obtained will have been made. It could therefore be of some benefit to recheck approximate affordability of the systems at this stage.

(3) Availability of equipment, materials and labour
These are similar to the availability of tools section discussed above.

(e) Acceptability of roofing types
All those roofing types that have passed the previous sub-module checks are now presented to the end-user. The end-user is asked to select (with the aid of a visual-guide if necessary) and indicate which roofing types they would like to investigate further.

A similar draft affordability for all the different shapes/designs (sub-units) of each UNITS Roofing type is undertaken in which the end-user is asked to select those which they find acceptable from within the list of affordable sub-units.

This completes SECTION A of running BUILDROOF, as indicated in figure 5.1.

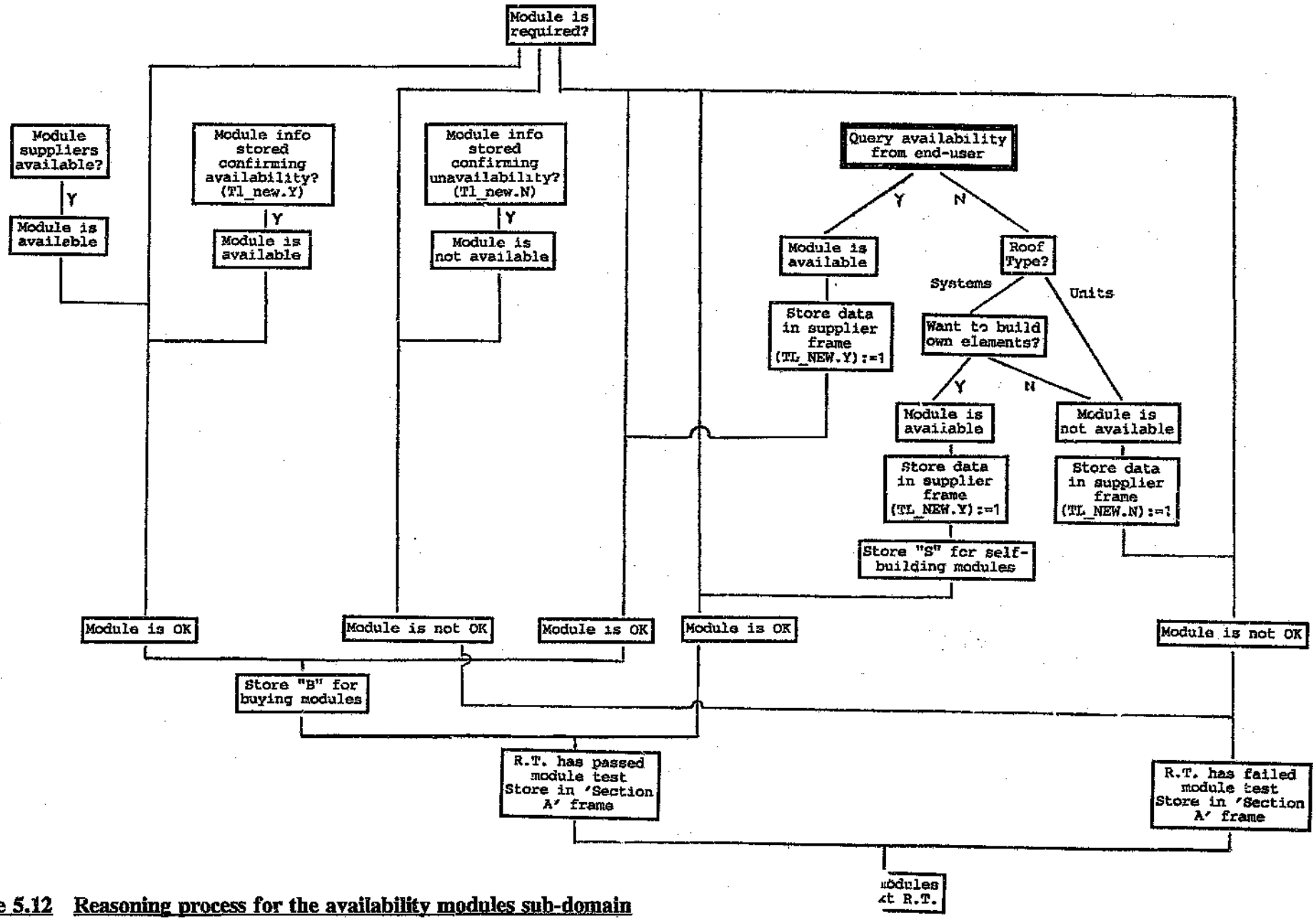


Figure 5.12 Reasoning process for the availability modules sub-domain

5.1.2 SECTION B OF RUNNING BUILDROOF

In this section, a more detailed costing of all those roofing types that were channelled down through Section A, is undertaken. This costing is done for each sub-unit in the case of a UNIT roofing type and each element in the case of a SYSTEM roofing type.

Before this detailed costing commences though, an approximate affordability check is again carried out. This check however varies from that carried out earlier (see section 5.1.1(iii) - Draft costing test) in that each sub-unit is now checked and the end-user class (i.e. self built, artisan or contractor) is considered in the check.

Since the availability of the goods and services required for each of the roofing types now being considered has already been verified, only the actual mode of availability and costs thereof still need to be identified. The mode of availability is queried using the qualifiers and values listed in table 5.3. All of these qualifiers offer as one of their values 'NOT KNOWN - INFO REQUIRED'. This option allows the end-user to view the 'information' frame, as discussed in sections 5.1.1(iv) and 5.4, corresponding to the good or service currently being queried about. An example of such an information frame (in this case for hammers) appears in figure 5.13. If suppliers are available, then information on where the goods or services are available from, the mode of availability and at what charge can be conveyed to the end-user. The end-user then returns to the qualifier-value options and selects the relevant mode of availability. Depending on what value of the qualifier is selected, rules querying the costs involved (if any) will be fired. If the value rentable, was entered, then the end-user will be asked as to whether it is on a daily or hourly basis.

Each time information is obtained in this costing section regarding the mode of availability chosen by the end-user for a certain good or service, it is stored in an end-user specific frame. Before querying the end-user on the mode of availability of any goods or services, this frame is checked. If data is available on the availability as already identified by the end-user, it will be used as opposed to querying the end-user again unneccessarily. Since this data is end-user specific, the frames are cleared at the end of each BUILDROOF run.

NOTE: (1) A zero(0) in these columns represents no availability
(2) All prices/costs in Rands and Cents

NO	NAME OF SUPPLIER	ADDRESS OF SUPPLIER	CONTACT NUMBER	RENTAL COSTS		SELLING PRICE
				DAILY	HOURLY	
1	Tools galore	Plot 401	0	7.00	1.50	25.00
2	Simon Spader	342 Ngoia Street	0	7.00	2.20	26.99
3	Henry's Hardware	1 Antad Street	0	0	0	23.89
4	---	---	0	0	0	0
5	---	---	0	0	0	0
6	---	---	0	0	0	0
7	---	---	0	0	0	0
8	---	---	0	0	0	0

Figure 5.13 Information screen

In this way the total cost of each goods or service is calculated from both these costs as well as the requirements of that good or

GOODS OR SERVICE	QUALIFIER	VALUES
Modules	[[MOD NAME]] is/are	* owned or obtainable free of charge * purchaseable * not obtainable * NOT KNOWN - INFO REQUIRED
Equipment	[[EQUIP NAME]]/s is/are	* owned or obtainable free of charge * purchaseable * rentable * not obtainable * NOT KNOWN - INFO REQUIRED
Materials	[[MAT NAME]]/s is/are	* owned or obtainable free of charge * purchaseable * not obtainable * NOT KNOWN - INFO REQUIRED
Tools	is/are s/any [[TOOL NAME]]/s:	* owned or borrowable i.e. zero cost * purchaseable * rentable * not obtainable * NOT KNOWN - INFO REQUIRED
Labour	[[LAB NAME]] labourers are	* obtainable free of charge * rentable * not obtainable * NOT KNOWN - INFO REQUIRED

Table 5.3 Qualifiers and values used for costing goods and services

service (stored in the goods and services required frames e.g figure 5.10 - tools required for units frame).

At the end of this section all sub-units and system building blocks will have been priced. Again a 10% variability factor is applied. If affordable, the individual costs of modules, equipment, materials, tools and labour are then stored ready for output.

In the case of SYSTEMS, the costs that have been calculated are per building block. Thus once again an affordable area is proposed to the end-user. If this is accepted, then the costs are stored ready for output.

Note: Factors as discussed in section 5.5 (ii) are applied to these costs to compensate for miscellaneous costs.

5.2 OUTPUT BUILDROOF RUN RESULTS

This option sends costs stored from the BUILDROOF run to the screen. The total cost is split up into the five categories i.e modules, equipment, materials, tools and labour. In this way the final predicted costs for all the roofing types, be they sub-units or systems, which passed all the steps can be viewed by the end-user.

5.3 CHANGE LOCATION

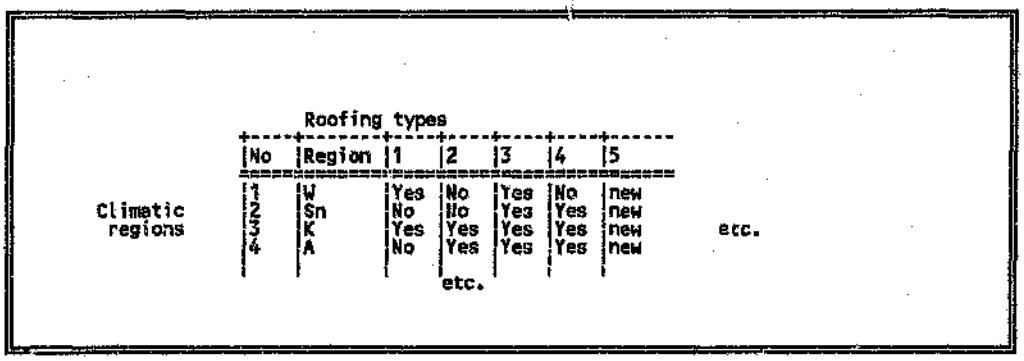
As discussed in section 5.1, the location in which the roofing type is to be used is vital when assessing the climatic suitability of roofing types.

This menu option allows the end-user, if necessary, to change the location and therefore repeat the process of reassessing the suitability of each roofing type to the new location.

In order to be able to do this though, formal climatic regions had to be identified. Several weather stations exist for which data has been collected. In order to break-down this immense amount of information it was decided to sub-divide South Africa into climatic regions. Several climatic classifications exist which have been devised for broad geographical purposes. A very comprehensive effort in that direction was made by Koppen[29] whose classification, which is based mainly on temperature and precipitation, has found widespread appeal by many including the South African Weather Bureau. Using the Koppen classification, the Weather Bureau has sub-divided South Africa into 12 regions. (See Appendix D for further details).

The towns in which weather stations exist, together with their corresponding climatic region, were stored in their province/homeland frames.

A frame, as shown in figure 5.14, containing the suitability of each roofing type to each of the 12 climatic regions is used to store this data.



Roofing types

	No	Region	1	2	3	4	5	
Climatic regions	1	W	Yes	No	Yes	No	new	
	2	Sn	No	No	Yes	Yes	new	
	3	K	Yes	Yes	Yes	Yes	new	etc.
	4	A	No	Yes	Yes	Yes	new	
				etc.				

Figure 5.14 Frame storing suitability of each roofing type to each region

On selecting this menu option, the current location is displayed, and the end-user is asked whether they wish to change the location. If they choose to do so, a list of provinces, homelands and states is presented to the end-user and the end-user is asked to select one. Having done this, the main towns/cities of that province/homeland/state will be presented and the end-user is asked to select the city or town closest to the location in which the house is to be built. In order to avoid potential end-user errors in spelling, each city or town was allocated a number and the end-user is requested to enter this number as opposed to typing in the name. The climatic region into which the city/town chosen falls is extracted from the province/homeland data frames. The suitability of each roofing type in the data base to the new location is obtained from the roofing system climatic suitability frame as shown in figure 5.14. (The method by which the suitability of each roofing type to each region is assessed, is described in section 5.6).

These values are then stored in the climatic suitability frame shown in figure 5.3.

In this way, the climatic suitability of the roofing types in the databases to the new location, are reassessed and updated.

5.4 INPUT OF DATA ON AVAILABILITY OF MODULES, EQUIPMENT, MATERIALS, TOOLS AND LABOUR

This option should ideally be executed by the operator and allows the operator to store details of availability and where applicable, details of suppliers of goods and services. This storage of data involves updating the following frames:

(i) The 'supplier frame' as discussed in section 5.1.1 (v)
(ii) The 'information frames' as discussed in section 5.1.1 (v)

The operator is queried as to which of the goods or services they wish to enter data on i.e. modules, equipment, materials, tools or labour and then more specifically the actual goods or service e.g. drilling machine from tools.

Once these have been selected, the relevant information frame is sent to the screen. The operator is asked to select the line in which the details of the new supplier are to be entered. Details on the supplier, costs etc. are then queried of the operator. These details are stored in the relevant 'information frame' and the supplier frame's *_SUP column is updated to indicate that details of at least one supplier are now available.

The approach adopted by allowing this flexibility in positioning the details was chosen for simplicity and convenience since it makes it possible to replace a supplier who is no longer available as well as to add a supplier onto the existing list without having to keep unnecessary records on exactly how many suppliers are already stored in the frame and therefore on which line the new supplier's details can be stored.

Since frames cannot be created from within an EXSYSPro run, empty 'information frames' were created at the outset so as to be available when required. The number of frames created corresponded with the number of information items allowed, as discussed in section 5.6.1. The ability to write data to outside of the frames could potentially have increased user friendliness. This was however not possible from within EXSYSPro.

This facility thus offers a way in which any member of a community can advertise any goods or services that they can offer. It also encourages competition amongst fellow suppliers.

5.5 DATA ON ACTUAL COSTS RETURNED

This option updates two values:

(i) Every time a new roofing type is introduced into BUILDROOF, an 'approximate' cost (as calculated by the expert), is entered. This cost is used for the draft costing check as discussed in section 5.1 (iii).

(ii) The total predicted cost of a roofing type as calculated in Section B is made up of five sub-costs i.e. modules, equipment, materials, tools and labour costs. In attempting to eliminate the difference between the predicted costs (as calculated during the BUILDROOF run) and the actual costs, factors accounting for miscellaneous costs are applied to each of these calculated sub-costs. In this way, cost predictions made during BUILDROOF runs should become progressively more accurate each time data is returned.

It was felt that costs and factors (accounting for miscellaneous costs) mentioned above, would differ depending on the end-user's category. Therefore a set of factors and approximate costs is kept for each end-user category of each roofing type.

Updating of the 'approximate costs' and the factors relies on end-users, who have run BUILDROOF (obtained predicted costs) and then built it (obtained actual costs), returning required data.

Predicted costs are displayed on the end-user's request once BUILDROOF has been run. Since the factors applied during the run will be required for calculating the new updated factors when and if data is returned, these factors are stored in a frame and a run number, relating to the storage place of the factors, is issued to the end-user. On returning data the end-user will be asked for this run number and the required data on factors applied at the time of running BUILDROOF can thus be retrieved. Dates of all three occurrences are queried of the end-user, that is:

* the running of BUILDROOF
* the actual building of the roof and
* the returning of the data

These dates are required for the purposes of deflating and inflating the actual costs as is discussed later. (For the sake of convenience inflation has been assumed at 15%).

The methodology used in updating costs and factors is as follows:

5.5.1 UPDATING DRAFT COSTS

In updating the draft cost, an average is taken between the stored draft cost (as stored at the time of returning data) and the actual (inflated to it's current value) cost incurred by the end-user.
In the case of the first set of data being returned, this inflated actual cost is given a weighting of 1 together with the weighting of 1 also given to the initial draft cost entered by the expert. However, every set of data entered thereafter is given a weighting of 1 together with the weighting of 5 given to the most recently updated cost.

5.5.2 UPDATING SUB-COST FACTORS

Had the predicted cost been accurate, then the actual cost deflated to the time of running BUILDROOF should be the same as the predicted cost. Failure to comply with this indicates that the factor applied at the time was erroneous. In this case, the factor used at the time of the run (and which was stored) will be corrected and used to update the current cost factors. This updating of current cost factors is done by taking an average between the current cost factors and the corrected cost factor used at the time of the run. Similarly to the updating of costs, in the case of the first set of data being returned, the corrected cost factor is given a weighting of 1 together with the weighting of 1 also given to the initial cost factor entered (the initial factors value which will have been set at one). When updating the factor thereafter, every new corrected cost factor calculated is given a weighting of 1 together with the weighting of 5 given to the most recently calculated and stored cost factor at the time of returning data.

It was decided to give values from new data (for both factors and costs) - with the exception of the first value - a lower weighting so as to minimise the possibility of a single faulty value causing large errors.

In order to clarify the methodology described above, an example follows:

Assume Joe, a contractor, has used the BUILDROOF package to select a roofing type for a house which he is building.

In January 1992, he ran BUILDROOF. The total modules cost calculated during the run was R1000.00. The modules factor for a contractor for the roof type selected at the time was 1.05. Applying this factor increased Joe's predicted cost for modules to

= R1000.00 x 1.05
= R1050.00

In April 1992, Joe constructed his roof. The actual cost incurred was R1150.00. R1150.00 deflated from April back to January

= R1150.00 x $(1.15)^{-0.25}$
= R1110.51

This shows that the initial factor applied did not fully account for all miscellaneous costs.

In July 1992, Joe returned the data back to the package. The actual cost incurred is used to update the cost and factor.
The actual cost incurred inflated to current costs

= R1150.00 x $(1.15)^{0.25}$
= R1190.89

Assuming that this set of data is not the first to be returned, this value gets a weighting of 1 and the most updated cost value at the time of returning the data (say R1140.00), a weighting of 5.

Thus,

$$NewFactor = \frac{1.11 + 5*1.12}{6} = 1.12$$

This process is repeated for all the sub-costs. The sum of these sub-costs is stored as the most up to date approximate cost and is used for draft testing the next run.

The factor applied to Joe's modules cost (i.e. 1.05) at the time of running is corrected as follows:

1110.51/1050 x 1.05
= 1.11

Assuming again that this set of data is not the first to be returned, this new factor gets a weighting of 1 and the most updated factor at the current time (say 1.12), a weighting of 5.
Thus,

$$NewCost = \frac{1190.89 + 5*1140}{6} = 1148.48$$

This process is repeated for all the sub-costs. The factors are stored as the most up to date approximate factors and are applied to the next runs costs.

In this way factors can be updated and more accurate draft costs can be calculated. Figure 5.15 outlines the manipulation of these cost factors and costs.

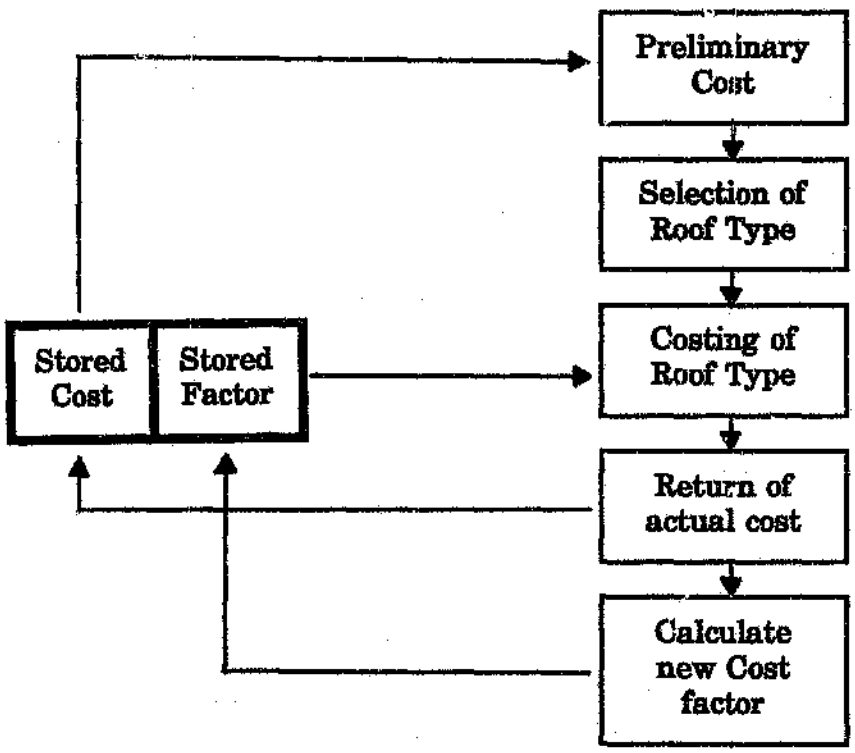


Figure 5.15 Manipulation of cost factors and costs

5.6 INPUTTING A NEW ROOFING TYPE

This allows BUILDROOF's database of roofing types to be expanded upon, thus allowing any roofing types (of a units or systems nature) that have not already been included as well as new roofing types that may be developed in the future to be incorporated. This therefore makes BUILDROOF independent of the original developer when adding a new roofing type (for systems and units only at this stage).

This option is carried out by merely supplying answers to questions as queried by the package and should ideally be done by an 'expert' in the new roofing type.

5.6.1 DATA SPACE ALLOCATION

EXSYSPro does not allow a new frame to be created during a run nor an existing frame to be expanded upon. For this reason, it was necessary to select the amount of space that would be allocated for data storage relating to new roofing types. Although no exact philosophy was used in deciding the amounts as tabulated in table 5.4, the four roofing types entered did offer guidelines in the ratios of space (for related data) to allow in relation to the number of roofing types. (The number of which was decided upon at the outset as 10).

This space was thus created and that of which is still available can be identified by the 'new' stored in it until it is required. It is into

these spaces that the data, related to a new roofing type, will be stored.

	Number
1. Maximum number of roofing types	x 10
Therefore total number module ranges e.g. USSR, Concrete blocks etc.	x 10
2. Maximum number of systems	x 6
3.1 Number of units	x 6
3.2 Number of sub-units (i.e. shapes)	x 25
3.3 Number of units' sub-modules / building blocks	x 20
4. Number of equipment	x 7
5. Number of materials	x 15
6. Number of tools	x 10
7. Number of labour types	x 8
8. Number of lines in 'information frames' for supplier details	x 8

Note: Points (3.3 - 7) determine the number of information frames created

Table 5.4 Space supplied for storage of data

5.6.2 COLLECTION OF DATA

The questions that are asked relate to each of the sub-domains discussed in 5.1. Since the 'structures' into

which this information entered is to be stored, have already been extensively discussed in this chapter, only a brief description of each is given below. Where necessary though, a more detailed description is given.

(a) Miscellaneous details

The 'expert' is queried with regards to details such as:

* Roofing type category i.e. system versus unit;
* names and areas of elements of systems or number of, names and areas of sub-units.

(b) Climate

In order to make possible the task of categorising a roof type as being either suitable or unsuitable to a location, it was necessary to attach certain characteristics to a roofing type which could be compared to a geographical location possessing those same characteristics. As discussed in section 5.3, data from the main weather stations in each region was averaged out and used as representing the average maximum and minimum temperatures and maximum rainfall for each region.

Thus when entering a new roofing type into the database, the maximum and minimum temperatures and maximum rainfall for which the roofing type is suited, is queried of the

expert. Comparing this data to that obtained for each Roofing type i.e. maximum & minimum temperatures and maximum rainfall for which it is suitable, it is possible to assess the suitability of the newly introduced roofing type to all of the twelve regions. This data is then stored into the frame in figure 5.14 ready for use.

During the latter part of the development, the author realised that the presence or lack of a ceiling (for roofing types where a ceiling is an optional extra) could influence the climatic suitability of a roofing type to a location. In order to attempt to compensate for this omission, the following was decided:

In assessing the suitability of those roofing types (for which a ceiling is an optional extra), the assumption is made that a ceiling is to be used and this is pointed out to the end-user when querying whether a ceiling is wanted. Although this assumption made is not totally unfeasible since facilities do exist for a ceiling, it may introduce problems if an end-user does not want a ceiling.

Ideally, the suitability of these roofing types should be calculated for both scenarios i.e ceiling present and no ceiling. In order to know which of the two cases would apply, the climatic suitability would have to be queried after the extras.

(c) Extras

The expert is queried as to the extra facilities that the new roofing type contains. These details are stored in the 'Extras frame' as depicted in figure 5.4 and as discussed in section 5.1.1(ii).

(d) Draft Costing

Draft Costs are queried of the end-user for the different end-user scenarios as discussed in section 5.1.1(iii). These costs are stored in either the units or systems frame as depicted in figures 5.7 and 5.8 respectively.

(e) Goods and Services required

The goods and services required for the different scenarios are queried:
In the case of systems, self-building the elements and purchasing elements and in the case of units, for each sub-unit(shape), the different end-user scenarios.

This is done by approaching each of the relevant above mentioned scenarios individually.

As discussed in section 5.1.1(v), the names of the actual goods and services (i.e. modules, equipment, materials, tools and labour) already documented as required for those roofing types already in the BUILDROOF database, are stored in the supplier frame as shown in figure 5.9.

Each of these five goods and services are handled in the same manner. Therefore, for the sake of simplicity in describing the process, the procedure involved in obtaining details on tools required will be described:

When querying the requirements of the new roofing type, a list of the tools already listed in the supplier frame is presented to the expert. The expert is asked to select from this list, one at a time, those tools required for the new roofing type. Details as depicted in table 5.2, regarding the tool chosen, are queried and stored in frames such as that shown in figure 5.10 in the case of tools required for the EFU unit range.

Once this is completed, the expert is asked whether any other tools are required which are not already listed in the supplier frame list of tools. If an affirmative answer is received, The expert is asked to enter the name of the tool and details, as described above, are queried.

The BUILDROOF 'database' currently has four roofing types stored in it (2 units and 2 systems). All four were entered using this menu option.

5.7 REMARKS

Various problem areas were identified during the development of BUILDROOF. These were largely due to certain scenarios having been overlooked during the knowledge engineering stage and thus, not having been catered for. The author felt that the major reason for this was that within the time that was available for the development thereof, too much detail was attempted for the broad scope that was covered.

Another problem encountered was EXSYSPro's inability to run BUILDROOF on some of the computers on which it was installed. Continued discussion with the dealers in New Mexico failed to reveal the reason. Such problems are extremely frustrating and should be avoided if possible. 'Problem' expert system shells can often be identified by discussing them with developers who have had hands on experience with them. This should be done prior to purchasing a shell. The author experienced this after completion of BUILDROOF.

These points should be borne in mind by anyone considering the development of an expert system.

6. EXPERIENCE WITH USE OF EXPERT SYSTEM

6.1 INTRODUCTION

This chapter documents feed-back from the parties involved in testing and validating BUILDROOF as well as feed-back on the suitability of expert systems in the context in which BUILDROOF was developed.

6.1.1 TESTING AND VALIDATING BUILDROOF

At various stages of it's development BUILDROOF was tested by the involved parties -the experts and the potential end-users. The purpose of this testing was to validate the results i.e. was BUILDROOF doing what it was meant to do and was it actually solving the problems that led to it's development.
This testing also turned up bugs and problems of many kinds and aided in making a number of necessary corrections.

6.1.2. FEED-BACK ON DEVELOPING AREAS CONTEXT OF BUILDROOF

Bearing in mind that the main purpose of this study, as detailed in chapter 1, was to investigate the use of expert systems in developing areas, feed-back regarding this issue was collected.

In addition, recommendations (where available) on potentially suitable areas of application were made.

6.2 EXPERTS AND POTENTIAL END-USERS

The experts body was represented by Mr Jorge Arrigone.

The potential end-users were represented by:

* Mr Joe Mogale from the African Builder's Association (ABA)
* Small scale contractors from the Contractor Development Agency (CDA).

Since Mr Arrigone is actively involved with the implementation of technical aid centres, he was also able to offer valuable feed-back from an end-user's point of view.

Feed-back from Dr Krige, the author's supervisor and a senior structures lecturer at the University of the Witwatersrand, was also documented.

6.3 FEEDBACK COLLECTED

Results and feedback from running the system with each of these parties was sought on issues applicable to individual parties. The points listed on the next page were used as a guideline.

(i) Does BUILDROOF do what it was meant to do?

- recalling from chapter 1, this was to offer expert guidance to an end-user (be they self-builders, artisans or contractors) in selecting one or a number of roofing types that best meet their requirements, limitations and needs within their financial constraints.

Does it solve the problem that led to it's development?

- Again recalling from chapter 1, the problem that led to it's development was the lack of available neutral expertise when selecting appropriate or alternative roofing types in developing areas.

(ii) Suitability of experts systems in this developing areas context. If suitable, the identification of potential areas where the use of expert systems appears plausible.

(iii) Miscellaneous ideas evolving from this project.

6.3.1 FEED-BACK FROM EXPERTS

(a) Independent Development Trust - Mr Arrigone

(i) Mr Arrigone was satisfied that BUILDROOF was achieving what it was developed to do and that the thought process behind the package was legitimate.

He felt that a package such as BUILDROOF did have a role to play in overcoming the lack of information readily available on the variety of roofing types available and the shortage of available expertise when selecting roofing types. However, the following points were made:

* It should be attached to a system covering all aspects of the house since these aspects are interrelated and therefore have to be dealt with together.

* The package aimed at a macro end-user body as apposed to micro (as BUILDROOF was) could also be useful in obtaining an overview of the type of roofing types that would be suited to an area. Possible end-user scenarios in this case would be a community representative or a party involved in the design process e.g. an engineer or architect. Bearing in mind though the time constraints of the author, and that this study was purely

of a pilot nature, he felt that for the purposes of 'marketing expert systems' in developing areas, a shallower approach but across all aspects of the house, could perhaps have more adequately illustrated the capabilities of expert systems and therefore aided in point (ii).

(ii) Mr Arrigone felt that expert systems could be of great use in developing areas. However he stressed that anything developed should be done in collaboration with a development organisation or structure.

The following fields were identified by him as being potentially suitable for expert system applications:

* Training of engineers for working in developing areas i.e. highlighting differences in the design process in these areas as compared to first world conventional scenarios.
* Marketing of alternative technology to engineers, architects, township developers etc. involved in these areas.

(iii) On the issue of the usage of computers and conventional software in developing areas, Mr Arrigone expressed interest in having an accounting package developed for usage in the Technical Aid Centres.

Dr Krige proposed that this be offered as an investigation project for the fourth year students and this proposal will be given further thought.

(b) Training of Engineers/Architects - Dr Krige

(i) With regards to BUILDROOF, Dr Krige pointed out the following shortcoming:
BUILDROOF's inability to check two locations for climatic suitability. This may be necessary if the end-user stipulates a temporary or movable roofing type.
Dr Krige expressed interest in adding rafters, trusses (self-made as apposed to purchased) and coverings to the BUILDROOF database.

(iii) Dr Krige felt that such a package could be useful for training and guiding architects and engineers involved in the designing of low-cost housing. However, since it would be used for training purposes, additional information geared at the requirements of these professions would have to be included.

6.3.2 FEED-BACK FROM POTENTIAL END-USERS

(a) African Builder's Association - Mr Joe Mogale

(i) Mr Mogale was confident that BUILDROOF had met it's objectives which from his perspective was to manipulate large amounts of information which are available into a form which is more useable to an end-user.

(ii) Mr Mogale expressed much optimism as to the potential future that expert systems could play in a developing areas context. Again, as with Mr Arrigone, he stressed that their development should be carried out together with an existing development organisation or within an existing structure.

Additional potential areas of application identified, over and above those already identified, included the following:

* expert systems to aid in ensuring orderly development and
* advice on selecting standards.

(b) Contractor Development Agency (CDA)

Due to the fact that these small scale contractors still have sufficient work in the formal, middle income housing sector, the informal, low-income housing sector (with it's associated problems) is not a market which they will willingly enter at this point.

Therefore, BUILDROOF's expertise in alternative roofing types would not be required. However, they felt that expertise on the more conventional rafters, trusses and

coverings could be very useful.

In retrospect though, they expressed confidence that BUILDROOF does have a place and could be useful in aiding end-users in selecting a roofing type. They also acknowledged that they felt that this was where housing construction works in the future would be available and that the key to supplying affordable housing would involve alternative methods such as incorporated in BUILDROOF.

7. CONCLUSIONS AND RECOMMENDATIONS

The following conclusions and recommendations can be drawn from this investigation:

1. Conventional roofing types currently 'own' the roofing market. These are not suited to the low income housing sector for a number of reasons:-

   * often they do not meet the requirements of the lower income home owner e.g core housing and maximum usage of locally available materials and skills;

   * they are not aimed at common lower income housing sector characteristics (e.g. low affordability, low level of expertise available) and

   * money leaves the community.

2. There exist a number of roofing types which have either been developed or are in the process of being developed and that are especially aimed at the lower income housing sector. These however do not appear to have been widely marketed and although documentation on some exists, it's existing form is not conducive to usage amongst the end-users that it is aimed at,

3. Experts having a broad knowledge of several roofing types and thus in a best position to offer guidance in the selecting of roofing types for individual end-users, are scarce. A need therefore exists for neutral unbiased advice in selecting roofing types which are best suited to an individuals requirements, needs and limitations.

4. From the feedback obtained from potential end-users and experts, it was felt that BUILDROOF was able to manipulate the roofing data available into a more useable form and in addition, offer neutral and unbiased expert advice in roofing selection.

5. Roofing however cannot be dealt with individually since it's selection is related to the remaining housing structure. In addition, the manner in which information and expertise on roofing selection has been encapsulated into BUILDROOF would be of equal benefit if applied to the selection of the remaining housing structure. Thus in order that an expert system such as BUILDROOF be of maximum benefit, it should be adapted to incorporate the whole housing structure.

   It was felt by some that BUILDROOF's database should be expanded to include trusses (self-made as apposed to purchased), rafters and coverings.

6. From the feed-back obtained, it was felt that expert systems appear suitable for usage in developing areas. The designing of any expert system should however be done in collaboration with a development agency or existing development structure.

7. Potential areas of application identified were:

* Training of engineers for working in developing areas i.e. highlighting differences in the design process in these areas as compared to first world conventional scenarios.

* Marketing of alternative technology to engineers, architects, township developers etc. involved in these areas.

* Offering of neutral and unbiased expert guidance to builders when designing/building a home.

* Advising on suitable selection of standards.

8. Various problem areas were identified during the development of BUILDROOF. These were largely due to certain scenarios having been overlooked during the knowledge engineering stage and thus, not having been catered for. The author felt that the major reason for this was that within the time that was available for the development thereof, too much detail was attempted for the broad scope that was covered.

Before purchasing an expert system shell, consultation should be carried out with developers who have had hands on experience with the shell since this may help in identifying and thus avoiding 'problem' expert system shells.

These points should be borne in mind by anyone considering the development of an expert system.

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APPENDIX A

A1 - UNTIEDT SUPPORT STRUT ROOFING

A1: USSR: UNTIEDT SUPPORT STRUT ROOFING

	USSR 15	USSR 30	USSR 45	USSR 60
GENERAL				
Total no. of foundations	4	6	8	9
No of foundations added	4	2	2	1
Area (m^2)	40	50	55	60
MODULES (Building blocks)				
Module A	x 1	x 1	x 1	x 1
Module B		x 1	x 1	x 1
Module C			x 1	x 1
Module D				x 1
MATERIALS (See Concrete mix calculations)				
Water (litres)	203	304	405	455
Cement (m^3)	0.072	0.108	0.144	0.162
Sand (m^3)	0.22	0.33	0.43	0.49
Stone (m^3)	0.43	0.65	0.86	0.97
TOOLS (# @ hours) (See Labour calculations)				
Spade	1@ 8.0	1@ 12	1@ 16	1@ 18
Hammer	2@ 4.0	2@ 8.0	2@ 12	2@ 16
Wheelbarrow	1@ 4.0	1@ 6.0	1@ 8.0	1@ 9.0
LABOUR (# @ hours) (See Labour calculations)				
Unskilled	1@ 8.0	1@ 12	1@ 16	1@ 18
Skilled	2@ 4.0	2@ 8.0	2@ 12	2@ 16

Table A1.1: Summary of required goods and services for USSR sub-units

(i) GOODS AND SERVICES CALCULATIONS

Note: All information used for calculations was obtained from the following:

(a) Mr Dalmien Untiedt, Sunshine Homes

(b) USSR Information sheets. *USSR : Untiedt Support Strut Roofing*. Johannesburg, 1992.

FOUNDATION SIZING

Check #1: Bearing pressure

Total mass (in kg) of roof for USSR 15
= (7x7.72)+(6x11.94)+(2x12.73)+(4x9.65)+3.57+9.55
= 202.8kg

Therefore mass per foundation = 202.8/4
= 50.7kg
= 500N

Assuming relatively adverse soil conditions, allowable bearing pressure = 50KPa

Therefore foundation area reqd = 500N / $50x10^3 N/m^2$
= 0.01 m^2
= 100mm x 100mm foundation

Check #2: Stability-Uplift

Wind Loading:
(SABS 0160)

Assuming a worst case scenario:

V = 50m/s

k = 0.6 — Assuming a 10 year return period and a category 3

$q_z = k(V_z)^2$

$= 0.6(50)^2 = 1500N/m^2$ — 4.5.3.1

External pressure coeffecient (C_{pe})

Monopitched roofs with h/w < 2

Roof angle = 5°

Therefore, maximum average C_{pe} for surface = -1.0 — Table 6

Internal pressure coeffecient (C_{pi})

Assume +0.3 since the exact positioning of openings will be decided by the home builder

Therefore $F_z = (C_{pe} - C_{pi})\ q_z\ A_z$

$= (-1.0 - 0.3)\ 1500N/m^2\ (3.0m \times 4.03m)$

$= 23.6\ kN$

Therefore

$Roof_{Dead\ Load} + Foundations_{Dead\ Load} >= 23.6kN/4$

$0.5kN + Foundations_{Dead\ Load} >= 5.9kN$

$Foundations_{Dead\ Load} >= 5.4kN$

Therefore volume concrete required per foundation
= 5.4kN / 24kNm^3
= 0.224 m^3
Therefore use 610mm x 610mm x 610mm foundations

MATERIALS

CONCRETE MIXES
(Calculated per foundation)

Volume of each foundation
(See Calculations for size of foundations)
= 610 x 610 x 610
= 0.23 m^3

Mix is 1:3:6 (cement : sand : stone)
Assuming 0.220m^3 water per m^3 for dry mix
Therefore 0.78m^3/m^3 mix is made up of cement, sand and stone

Therefore per foundation:

Water	= 0.220 x 0.23 = 0.0506 m^3	= 50.6 l
Cement	= 0.78 x 0.23 x (1/10)	= 0.018 m^3
Sand	= 0.78 x 0.23 x (3/10)	= 0.054 m^3
Stone	= 0.78 x 0.23 x (6/10)	= 0.08 m^3

Therefore volumes of materials
= Number of foundations x above values

LABOUR AND TOOLS

* Digging of foundations

Assuming average soil conditions, it is estimated that an average worker can dig $1m^3$ in 4 hours. (1)

Each foundation (610mmx610mmx610mm) should take 1 unskilled labourer $(0.61m)^3$ x 4 hours

= 0.91 hours

= Approximately 1 hour.

A spade is required for the full hour.

* Pouring of foundations

The mixing and pouring of concrete for each foundation should take 1 unskilled labourer approximately 1 hour.

A spade and a wheelbarrow is required for the full hour.

* Erection of modules

The erection of each $15m^2$ module should take approximately 4 hours and would require the services of 2 Skilled labourers.

Two hammers are required for the full duration.

(1) BKS - Johannesburg - Labour Intensive construction projects

(ii) SUB-UNIT COST CALCULATIONS

Building block prices quoted by the suppliers were as follows:

Module A	=	R 1800.00
Module B	=	R 1500.00
Module C	=	R 1400.00
Module D	=	R 1400.00

These prices excluded VAT, distribution costs, profits and additional erection costs.

The following assumptions were made by the expert in calculating approximate total costs as reflected in Table A :

Distribution fee + profit	=	+ 20%
VAT	=	+ 10%

Erection Costs:

Contractors	=	+ 10%
Artisans	=	+ 12.5%
Self-builders	=	+ 15%

RS	UNIT	UNIT_NAME	NO	UNIT_NO	UNIT_TYPE	AREA	UN	COST		
								SELF	ART	CONT
2	2	USSR	13	1	USSR 15	15	m2	2735	2673	2615
2	2	USSR	14	2	USSR 30	30	m2	5010	4900	4790
2	2	USSR	15	3	USSR 45	45	m2	7135	6980	6825
2	2	USSR	16	4	USSR 60	60	m2	9260	9060	8860

Table A1.2: Frame containing EFU Sub-Unit costs as predicted by expert

A2 - EVERTILE FAST FRAME UNITS

A2: EFU: EVERTILE FAST-FRAME UNITS

	T40	T50	T40+T15	T60
GENERAL				
No. of foundations	4	4	6	4
Area (m^2)	40	50	55	60
MODULES (Building blocks)				
EFU T15			x 1	
EFU T40	x 1		x 1	
EFU T50		x 1		
EFU T60				x 1
EFU T70				
MATERIALS (See Materials required calcs)				
Water (litres)	190		285	190
Cement (m^3)	0.07		0.1	0.07
Sand (m^3)	0.2		0.3	0.2
Stone (m^3)	0.4		0.6	0.4
TOOLS (# @ hours) (See Labour+tools required calcs)				
Spade	1@8hrs		1@ 12.0	1@ 8.0
Hammer	2@ 2.5		2@ 5.0	2@ 2.5
Spanner	2@ 2.5		2@ 5.0	2@ 2.5
Drill	2@ 2.5		2@ 5.0	2@ 2.5
Pop Riveter	2@ 2.5		2@ 5.0	2@ 2.5
EFU Lifting Jack	2@ 2.5		2@ 5.0	2@ 2.5
LABOUR (# @ hours) (See Labour & tools calcs)				
Un-skilled	1@ 8.0		1@ 12.0	1@ 8.0
	+		+	+
	2@ 2.5		2@ 5.0	2@ 2.5
Total	1@ 13		1@ 22	1@ 13
Skilled	2@ 2.5		2@ 5.0	2@ 2.5

Table A2.1: Summary of required goods and services for EFU sub-units

	T50+T15	T70	T40+ 2xT15	T60+T15
GENERAL				
No. of foundations	6	4	8	6
Area (m^2)	65	70	70	75
MODULES (Building blocks)				
EFU T15	x 1		x 2	x 1
EFU T40			x 1	
EFU T50	x 1			
EFU T60				x 1
EFU T70		x 1		
MATERIALS (See Materials required calcs)				
Water (litres)	285	190	380	285
Cement (m^3)	0.1	0.07	0.14	0.1
Sand (m^3)	0.3	0.2	0.4	0.3
Stone (m^3)	0.6	0.4	0.8	0.6
TOOLS (# @ hours) (See Labour+tools required calcs)				
Spade	1@ 12	1@ 8.0	1@ 16	1@ 12
Hammer	2@ 5.0	2@ 2.5	2@ 7.5	2@ 5.0
Spanner	2@ 5.0	2@ 2.5	2@ 7.5	2@ 5.0
Drill	2@ 5.0	2@ 2.5	2@ 7.5	2@ 5.0
Pop Riveter	2@ 5.0	2@ 2.5	2@ 7.5	2@ 5.0
EFU Lifting Jack	2@ 5.0	2@ 2.5	2@ 7.5	2@ 5.0
LABOUR (# @ hours) (See Labour+tools required calcs)				
Unskilled	1@ 12	1@ 8.0	1@ 16	1@ 12
	+	+	+	+
	2@ 5.0	2@ 2.5	2@ 7.5	2@ 5.0
Total	1@ 22	1@ 1	1@ 31	1@ 22
Skilled	2@ 5.0	2@ .	2@ 5.0	2@ 5.0

Table A2.1 ctd...

(i) GOODS AND SERVICES CALCULATIONS

Note: All information used for calculations was obtained from the following:

(a) Mr Martin Dochety from Everite

(b) EFU Information sheets. *Evertile Roofing System + fast frame unit*. Spartan, 1992.

MATERIALS

CONCRETE MIXES
(Calculated per foundation)

Volume of each foundation
= 600 x 600 x 600
= 0.216 m^3

Mix is 1:3:6 (cement : sand : stone)
Assuming 0.220m^3 water per m^3 for dry mix
Thus 0.78m^3/m^3 mix is made up of cement, sand and stone
Therefore per foundation:

Water	= 0.220 x 0.216 = 0.0475 m^3	= 47.5 l
Cement	= 0.78 x 0.216 x (1/10)	= 0.017 m^3
Sand	= 0.78 x 0.216 x (3/10)	= 0.051 m^3
Stone	= 0.78 x 0.216 x (6/10)	= 0.101 m^3

Therefore volumes of materials
= Number of foundations x above values

LABOUR AND TOOLS

* Digging of foundations:

Assuming average soil conditions, it is estimated that an average worker can dig $1m^3$ in 4 hours.

Each foundation (600mmx600mmx600mm) should take 1 unskilled labourer approximately $(0.6m)^3$ x 4 hours
= 0.86 hours
= Approximately 1 hour
A spade is required for the full hour.

* Pouring of foundations:
The mixing and pouring of concrete for each foundation should take 1 unskilled labourer approximately 1 hour
A spade is required for the full hour.

* Erection of modules:
The erection of each module should take approximately 2.5 hours and would require the services of 2 skilled + 2 unskilled labourers
Approximately 2 hammers, 2 spanners, 2 drills, 2 popriveters and 2 EFU lifting jacks are required for the full duration.

(ii) SUB-UNIT COST CALCULATIONS

Building block prices quoted by the suppliers were as follows:

EFU Type 40	=	R 7804.00
EFU Type 50	=	R 8846.00
EFU Type 60	=	R 9895.00
EFU Type 70	=	R 10980.00
EFU Type 15	=	R 2443.00

These prices included 10% VAT and profit but excluded distribution and additional erection costs.

The following assumptions were made by the expert in calculating the approximate total costs as reflected in Table A :

Distribution fee	=	+ 8%
Erection Costs:		
Contractors	=	+ 10%
Artisans	=	+ 12.5%
Self-builders	=	+ 15%

RS	UNIT	UNIT_NAME	NO	UNIT_NO	UNIT_TYPE	AREA	UN	COST		
								SELF	ART	CONT
1	1	Evertile Fast-Frame Unit	1	1	EFU T40	40	m2	9695	9480	9270
1	1	Evertile Fast-Frame Unit	2	2	EFU T50	50	m2	10985	10750	10510
1	1	Evertile Fast-Frame Unit	3	3	EFU T40+T15	55	m2	12725	12450	12175
1	1	Evertile Fast-Frame Unit	4	4	EFU T60	60	m2	12290	12025	11755
1	1	Evertile Fast-Frame Unit	5	5	EFU T50+T15	65	m2	14020	13715	13410
1	1	Evertile Fast-Frame Unit	6	6	EFU T70	70	m2	13635	13340	13045
1	1	Evertile Fast-Frame Unit	7	7	EFU T40+2*T15	70	m2	15760	15420	15075
1	1	Evertile Fast-Frame Unit	8	8	EFU T60+T15	75	m2	15325	14990	14660
1	1	Evertile Fast-Frame Unit	9	9	EFU T50+2*T15	80	m2	17055	16685	16315
1	1	Evertile Fast-Frame Unit	10	10	EFU T70+T15	85	m2	16670	16310	15945
1	1	Evertile Fast-Frame Unit	11	11	EFU T60+2*T15	90	m2	18360	17960	17560
1	1	Evertile Fast-Frame Unit	12	12	EFU T70+2*T15	100	m2	19705	19275	18850

Table A2.2 : Frame containing USSR Sub-Unit costs as predicted by expert

A3 - CONCRETE HOLLOW BLOCKS

A3: CONCRETE HOLLOW BLOCKS

Note: All information used for calculations was obtained from the following:

(a) Mr Jorge Arrigone from the Development Bank of South Africa

(b) CSIR. Report ERR 642. *Low Cost Housing.* Pretoria, 1992.

(c) CSIR. Report S.199/24. *Research at local level : Description of a NBRI experimental project.* Pretoria, 1992.

ALL VALUES HAVE BEEN CALCULATED AS APPROXIMATE VALUES PER ELEMENT (3.26 m length and 0.815m^2 area)

If the end-user wishes to purchase the elements as apposed to producing them, then the details on goods and services marked with a (B) will be required.

Alternatively, if the end-user wishes to manufacture their own concrete elements, then the details on goods and services marked with an (S) will be required.

	PURCHASE (B)	SELF-BUILDING (S)
MODULES		
1.Block beams	One	N/A
EQUIPMENT		
1.Minimum normal scaffolding	Assume scaffolding is required for 1 hour per beam (this takes into account erection time of scaffolding etc.	Same as left
2.Block mould	N/A	Casting and stripping each beam = 2hours 15mins = 2.25hours

MATERIALS (See Calcs)		
1.Steel reinforcement 0=4.5mm	N/A	6.52m
2.Steel reinforcement 0=6.0mm	N/A	6.52m
3.Water	N/A	12.8 + 9 =21.81
4.Cement	N/A	0.005 + 0.0046 = 0.096m^3
5.Sand	N/A	0.009 + 0.04 = 0.049m^3
6.Stone	N/A	0.018m^3
7.Welded mesh reinforcing	0.82m^2	0.82m^2
8.Thin polyester fibre matt	0.82m^2	0.82m^2
9.Paint	0.5 litre	0.5 litre
TOOLS (# @ hours) 1.Level	1 @ 0.5 hour	1 @ 0.5 hour
LABOUR (# @ hours)		
1. Skilled	1 @ 1 hour	1 @ 1 hour
2.Unskilled	3 @ 1 hour	2 @2hrs15mins + (2+3) @1hr = 1 @ 9.5hrs

Table A3.1: Summary of required goods and services for Concrete Hollow Blocks

(i) GOODS AND SERVICES CALCULATIONS

EQUIPMENT

MINIMUM NORMAL SCAFFOLDING

Scaffolding is required for approximately 1 hour per beam (this takes into account erection time of scaffolding etc.

BLOCK MOULD

If self-building, then a block mould is required. Casting and stripping of each beam requires approximately 2 hours 15mins

MATERIALS

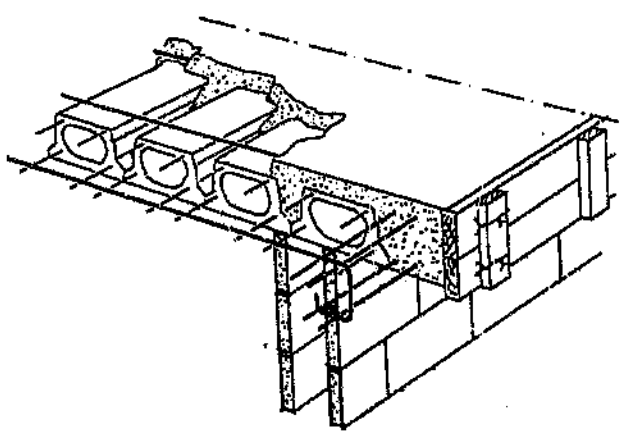

Fig A3.1: Cross-sectional view of Concrete Hollow Blocks

CONCRETE MIXES

Deal with all areas first:
(See Fig A3.1 for dimensions)

HOLLOW BLOCKS

Approx. volume of each block
= [2(230x30) + 2(70x30)] x 190mm length
= 0.00342 m^3 x 17 blocks
= 0.0581 m^3

Mix is 1:8 (cement : coarse river sand)
Assuming 0.220m^3 water per m^3 for dry mix
Therefore 0.78m^3/m^3 mix is made up of cement and sand

Therefore per trough:
Water = 0.220 x 0.0581 = 0.0128 m^3 = 12 l
Cement = 0.78 x 0.0581 x (1/9) = 0.005 m^3
Coarse River Sand = 0.78 x 0.0581 x (8/9)
= 0.04 m^3

STEEL REINFORCEMENT

If self-building, each element requires the following steel reinforcement along it's 3.26 m length:

* 2 x 6mm diameter
* 2 x 4.5mm diameter

Therefore each beam requires:
6.52m (diam = 6mm)
6.52m (diam = 4.5mm)

SEALING OF RE-BARS

Assume negligible

INFILL BETWEEN BLOCKS

Approximate volume of infill
= [(20 x 130)+(40 x 250)] x 17
= 0.041m³

Mix is 1:2:4 (cement:sand:stone (12-15mm))
Assuming 0.22m³ water per m³ for dry mix

Water	= 0.22 x 0.041 = 0.009 m³	= 9.0 litres
Cement	= 0.78 x 0.041 x (1/9)	= 0.0046 m³
Sand	= 0.78 x 0.041 x (2/9)	= 0.0091 m³
Stone	= 0.78 x 0.041 x (6/9)	= 0.0183 m³

WELDED MESH REINFORCING

For both (S) and (B) cases No. 078, 4.5mm bars @ 200mm centres - both directions is required over the full area. Therefore, per beam
= 0.25m x 3.25m
= 0.82 m²

THIN POLYESTER FIBRE MATT

For both (S) and (B) cases a polyester fibre matt is required over the full area of each beam.
Therefore, per beam = 0.82 m²

PAINT

Thin polyester fibre matt above is to be impregnated with acrylic paint and finished with a coat of ordinary paint. Approximately 0.5 litre of acrylic paint is required per beam.

TOOLS

LEVEL

1 level is needed throughout erection (approximately 0.5 hour)

LABOUR

(i) Casting & stripping:

Each block takes approximately 8 mins

Therefore per beam of 17 blocks = 17 x 8 mins

= 2 hrs 15 mins

Casting & stripping requires 2 unskilled labourers

(ii) Assembly of beams:

Assemblying of 1 beam takes approximately 1 hour and requires 2 unskilled labourers

(iii) Erection:

Erecting of each beam and covering etc. takes approximately 1 hour and requires 3 unskilled + 1 skilled labourer

1. SKILLED

   (See Labour calcs)

   (B) 1 reqd for 1 hour

   (S) 1 reqd for 1 hour

2. UNSKILLED

   (See Labour calcs)

   (B) 3 reqd for 1 hour

   (S) ((2 @ 2 hours 15 mins)+(2 @ 1 hour)+(3 @ 1 hour))

   = same as 1 reqd for 9.5 hours

(ii) DRAFT COST CALCULATIONS

In 1978, costs encountered on an American sponsored project were $16.33/m2. In order to convert this cost to a present day value, the exchange rates then and now were used.

	Exchange Rate
1978	$1.15 ---> R1.00
1993	$0.33 ---> R1.00

Table A3.2: Exchange Rates

Therefore approximated 1993 cost = 16.33 x (1.15/0.33)
(per m^2) = 16.33 x (3.48)
= R 56.83

Adding 20% as an adjustment due to prevailing conditions at time of costing = R 56.83 x 1.2
= R 68.20 / m^2

Therefore approximate cost per element if self-manufactured = 0.815 x R 68.20
= R 55.60

and approximate cost per element if purchased (assuming a 20% profit margin) = 1.2 x R 55.60
= R 66.70

NOTE: It was felt that for the purpose of this expert system, the method used in calculating a present day cost was accurate enough. A more accurate cost however, could be obtained based on goods and services required, as calculated.

A4 - PRECAST CONCRETE TROUGHS

A4: PRECAST TROUGHS

Note: All information used for calculations was obtained from the following:

(a) Mr Jorge Arrigone from the Development Bank of South Africa

(b) CSIR. Report BRR 642. *Low Cost Housing.* Pretoria, 1992.

(c) CSIR. Report S.199/24. *Research at local level : Description of a NBRI experimental project.* Pretoria, 1992.

ALL VALUES HAVE BEEN CALCULATED AS APPROXIMATE VALUES FOR 1 TROUGH (4.27m length and 1.225m^2 area)

If the end-user wishes to purchase the troughs as apposed to producing them, then those marked with a (B) will be required.

Alternatively, if the end-user wishes to manufacture their own concrete troughs, then those items marked with an (S) will be required.

	PURCHASE (B)	SELF_BUILDING (S)
MODULES 1.Concrete trough	One	N/A
EQUIPMENT 1.Minimum normal scaffolding	0.75hr	0.75hr
2.Trough mould	N/A	4.15hrs

MATERIALS		
1.Steel reinforcement Ø=4.0mm	N/A	29.9m
2.Steel reinforcement Ø=3.3mm	N/A	6.75m
3.Water	N/A	11+1.5+1.1=13.6l
4.Cement	N/A	0.01+0.0013+0.001 =0.0123m^3
5.Sand	N/A	0.028+0.003 =0.031m^3
6.Gravel	0.19m^3	0.0039+0.19=194m^3
7.Poly-ethylene sheeting	1.90m^2	3.80m^2
8.B.I.F.P. joint sealant	770cm^3	770cm^3
TOOLS (# @ hours)		
1.Trowels	N/A	2 @ 0.33hr
2.Level	1 @ 0.75hr	1 @ 0.75hr

LABOUR (# @ hours)		
1.Skilled	1 @ 0.75hr	1 @ 1.5hr
2.Unskilled	4 @ 0.75hr	1 @ 7hrs

Table A4.1: Summary of required goods and services for Precast Concrete Troughs

(i) **GOODS AND SERVICES CALCULATIONS**

EQUIPMENT

MINIMUM NORMAL SCAFFOLDING

Assume scaffolding is required for ~45 minutes per trough (this takes into account erection time of scaffolding etc.

Scaffolding is required regardless of whether the troughs were self-built or purchased.

MOULD

If self-building the troughs, a moulds is required for approximately 4.15hrs per trough i.e.

Casting each unit = ~20 mins
Mortar to take set = ~70 mins
Leave for 24 hrs, therefore = 2.4 hrs each
Stripping = ~15 mins each
TOTAL = 4.15 hrs each

MATERIALS

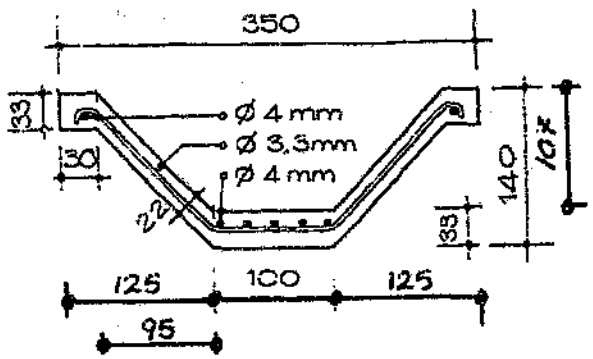

Fig A4.1: Cross-sectional view of Concrete Trough element

CONCRETE MIXES

Deal with all areas first:

(See Fig A4.1 for dimensions)

TROUGHS

Approximate volume of each trough

= [(100x33)+2(143x22)+2(30x33)-7(3.14x4/4)]x4270 - (6750x3.14x3.3/4)

= 0.049 m^3

Mix is 1:3 (cement : sand(6mm sieve))

Assuming 0.220m^3 water per m^3 for dry mix

Therefore 0.78m^3/m^3 mix is made up of cement and sand

Therefore per trough:

Water = 0.220 x 0.49 = 0.011 m^3 = 11 litres

Cement = 0.78 x 0.049 x (1/4) = 0.01 m^3

Sand = 0.78 x 0.049 x (3/4) = 0.028 m^3

SHAPED PRECAST CLOSING PIECES (SPCP) (NO FINES)

Assume width = 120mm

Volume of each SPCP = $0.028m^2$ x 0.12m
(See pg 2 no.5 for derivation of 0.028 value)
= 0.003348 m^3 x 2
(One on each side)
= $0.0067m^3$

Mix is 1:3 (cement : gravel(18-22mm)) No fines
Assuming $0.22m^3$ water per m^3 for dry mix
Water = 0.22 x 0.0067 = 0.0015 m^3 = 1.5 litres
Cement = 0.78 x 0.0067 x (1/4) = 0.0013 m^3
Gravel = 0.78 x 0.0067 x (3/4) = 0.0039 m^3

SHAPED PRECAST FILLING BLOCKS (SPFB)
Assume width = 120mm
Volume of each SPFB = [(60 x 107)+(95 x 107)]x0.120
= $0.0025m^3$ x 2
(One on each side)
= $0.005m^3$

Mix is 1:3 (cement : sand) As for trough
Assuming $0.22m^3$ water per m^3 for dry mix
Water = 0.22 x 0.005 = 0.0011 m^3 = 1.1 litres
Cement = 0.78 x 0.005 x (1/4) = 0.001 m3
Sand = 0.78 x 0.005 x (3/4) = 0.003 m^3

STEEL REINFORCEMENT
If self-building, each element requires 7 x 4mm diameter rods along its length.
Therefore 4.27m x 7 = 29.9m (Diam = 4mm)

In addition, stirrups are required at 300mm spacings.

Therefore # stirrups required = [(4270/300)+1]
= 15
Length of each stirrup = ~ 100 +2 [95 +124] +60
= 450mm
Therefore total length rqd = 0.45m x 15
= 6.75m (diam = 3.3mm)

GRAVEL (18-22 mm)

In the case of purchasing as well as self-building elements, gravel covering is specified to be 20mm thick and to fill trough cavities. Therefore volume reqd

= [(100 x 107)+(95 x 107)+(350x20mm thk) x 4.27m
= 0.028 m^2 x 4.27m
= 0.19 m^3

In addition, if self-building, gravel is required for the SPCP's.

POLYETHYLENE SHEETING

Sheeting is used to cover roof. Therefore area reqd per trough is the surface area

= [0.1m^2 + 2(95 + 107) + 2(30)] x 4.27m
= 1.90 m^2

In addition, if self-building, sheeting is used to seperate troughs (same area as above). Therefore area reqd per trough = 2 x 1.90 m^2
= 3.80 m2

BITUMEN INPREGNATED FOAM PLASTIC JOINT SEALANT

A 12x15mm strip of bitumen impregnated foam plastic joint sealant is specified

= 0.012 x 0.015 x 4.27m
= 770cm^3

TOOLS

TROWELS

If self-building, 2 trowels are required for approximately 20 mins each.
(See labour calculations for times - (Casting of each trough))

LEVEL

In either case 1 level is required throughout erection i.e. 1 level for approximately 45 minutes
(See labour calculations for times)

LABOUR

Production:

Casting each unit	= 20 mins
Moving etc.	= 10 mins
Stripping	= 15 mins
Total	= 45 mins

Casting & moving etc. requires 6 unskilled labourers + 1 skilled
Stripping requires 4 unskilled labourers + 1 skilled

Erection:

Erection of unit + covering etc. = 45 mins
This procedure requires 4 unskilled labourers + 1 skilled

Therefore, summary of labour required per element:

SKILLED

(See Labour calcs)

(B) 1 reqd for 45 mins

(S) 1 reqd for 90 mins

UNSKILLED

(See Labour calcs)

(B) 4 reqd for 45 mins

(S) ((4 @ 45 mins)+(6 @ 30 mins)+(4 @ 15 mins))
= same as 1 reqd for 7 hours

(ii) DRAFT COST CALCULATIONS

In 1978, costs encountered on an American sponsored project were $16.33/m2. In order to convert this cost to a present day value, the exchange rates then and now were used.

Considering the exchange rates documented in Table A3.2,

an approximated 1993 cost (per m^2) = 7.95 x (1.15/0.33)
= 7.95 x (3.48)
= R 27.70

Adding 20% as an adjustment due to prevailing conditions at time of costing = R 27.70 x 1.2
= R 33.20 / m^2

Therefore approximate cost per element if **self-manufactured** = 1.25 x R33.20
= R 40.00

and approximate cost per element if **purchased** (assuming a 20% profit margin) = 1.2 x R40.00
= R 48.00

NOTE: It was felt that for the purpose of this expert system, the method used in calculating a present day cost was accurate enough. A more accurate cost however, could be obtained based on goods and services required, as calculated.

APPENDIX B

BUILDROOF USER'S MANUAL

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1. GETTING STARTED

Insert the BUILDROOF diskette into the drive from which you will be working e.g. B.

If the computer is currently operating on another drive e.g. C, then convert to the B drive by typing the following:
C:\> **B:** and then pressing **<ENTER>**

The following will appear:
B:\>

To run BUILDROOF, type **<BUILDROOF>** and then press **<ENTER>**. A screen will appear with the message **"READING RULES"** displayed in the centre. This screen will remain present for approximately 1 minute, after which you will be asked whether you wish to have instructions on running the program. Press **<ENTER>**.

The next two screens (i.e. the 'Title & Author' and 'Subject of the Expert System' screens) are introductory screens containing information on BUILDROOF. Once you have finished examining the contents of each screen, press **<ENTER>** to activate the next screen.

You will now be faced with the Menu screen containing the six options offered by BUILDROOF. It is from this screen that these options are activated:

1. Run BUILDROOF
2. Output results from BUILDROOF run
3. Reset location details
4. Input information on the availability of modules, equipment, materials, tools or labour
5. Input Cost Details
6. Inputting a new Roofing Type
7. Exit to DOS

Each of these options is discussed further in Section 3.

2. INTERACTING WITH BUILDROOF

BUILDROOF can be run by anyone with essentially no training other than how to start the program - this topic having already been covered in Section 1 - 'Getting Started'. However, before you proceed to actually selecting menu options, the following information regarding your interacting with the BUILDROOF software may be of use.

2.1 END-USER INPUT MECHANISMS

Once the initial screens have been displayed, and a menu option selected, the BUILDROOF expert system will be activated. This will eventually result in the program requiring some input data. There are two standard types of questions you may be asked: multiple choice and numeric or string questions.

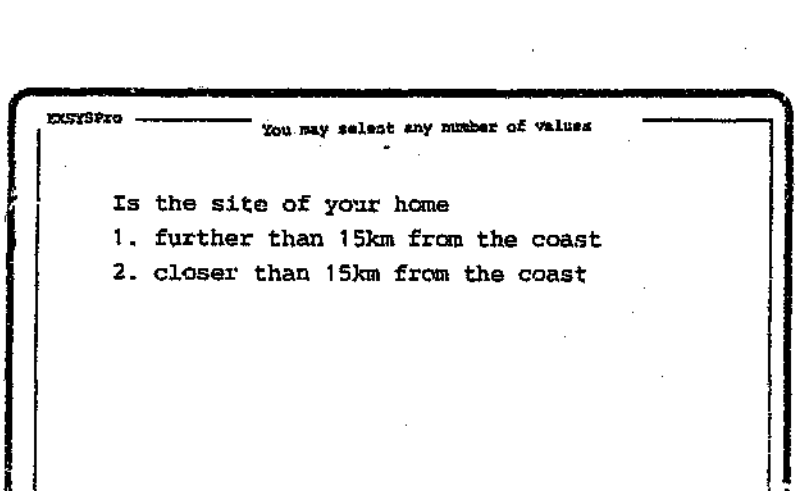
(i) Multiple Choice Questions

Multiple Choice questions display a statement, usually ending in a verb, followed by a numbered list of possible completions of the sentence. An example of such a question is depicted in Screen 1.

There are two ways to select a value from the list.

You can press the ↑ and ↓ keys to highlight the desired value, then press <ENTER>. Alternatively, you can enter the number or numbers of the values pertaining to your

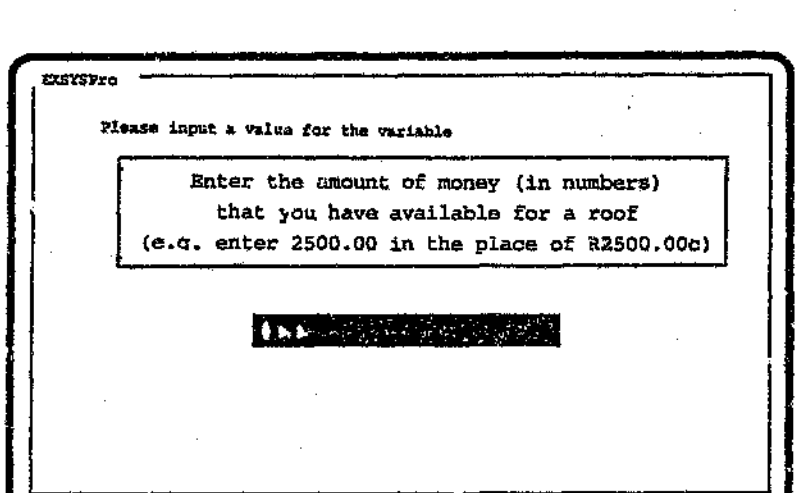
situation and press the **<ENTER>** key. If more than one number is chosen, separate the numbers with a space or comma or if highlighting, press the **SPACE BAR** on every item desired and on the last item desired, press **<ENTER>**. The top line of the screen will tell you if you can select any number of values, only a single value or some other limit such as no more than two values.



Screen 1: Multiple Choice Questions

(ii) Questions requiring Numeric or String data

The other type of question you may be asked is for a numeric value or a text string, an example of which is depicted in Screen 2. There will be an explanation of what information the program needs and a space to enter the value. Type in your answer and press **<ENTER>**.



Screen 2: Questions requiring Numeric or String Data

2.2 EXPLANATION SCREENS

Highlighted words on a screen indicate that information on the words is available. If you wish to know about one of the words, press the **<F1>** key. This will display the first keyword on the page. If this is not the word you want, continue pressing **<F1>** until the desired word is displayed. Then press **<ENTER>**. A screen containing information on the word will be displayed. Pressing **<ESC>** will take you out of this screen and back to the original screen.

3. BUILDROOF MENU OPTIONS

To run a menu option, type in the number corresponding to your choice and press <ENTER>. (See page 2 for menu options)

Option 1: RUN BUILDROOF

This constitutes the body of the BUILDROOF software package. Running of BUILDROOF is the option which you should run if you are wanting information on roofing types that meet your requirements as well as constraints.

The running of this option consists of two major sections, selection and costing.

The first section, Section A, consists of a selection process in which roofing types not meeting a number of criteria are eliminated.

The second section, Section B, consists of relatively detailed costing of those roofing types that passed through the selection process. From these results, those that are found to be affordable to you, are stored for later retrieval.

Each section will be discussed in more detail:

Note: Before you commence with this option, ensure that the location details currently in use, are correct. Do this by running Option 3 i.e. Reset Location Details

SECTION A

(i) Climatic Suitability

In this step the full range of roofing types currently in the database is checked for their suitability to the specific location selected by you.
No input will be required from you.

(ii) Extra features wanted by you

Your requirements with regards to roofing facilities will be queried. You will be asked to supply information on the following:

- whether your walls have already been built

- spans of walls
- type of walling material
- whether you want a roofing type suited to core-housing
- whether you want a roofing type suited to core-housing
- if you live in a coastal area you will be asked whether you live within a certain distance of the coast
- whether you require ceilings
- whether you require gutters
- what type of roof slope you want

Simply reply to these questions.

(iii) Draft costing test

You will be asked how much money you have available for the roof. An "approximate" check on the affordability of each roofing type can now be done.

In the case of UNITS, the smallest of the sub-units is checked for affordability. If it passes there is a chance that others may too, whereas if it fails, so will all others.
No input will be required from you in the case of the sub-units.

In the case of SYSTEMS, the acceptability of an approximate area that can be afforded will be proposed to you and you will be asked to either reject or accept this 'approximate' proposal.

(iv) Availability of goods and services

BUILDROOF stores information on the availability of local suppliers of goods and services. At this stage, only if no information on the availability of a goods or service is available in BUILDROOF's data storage mechanisms, will you be queried as to it's availability. If no data is available and you do not know of any suppliers, then the assumption will have to be made that none exists.

Simply select either <Yes> or <No> in answering all questions in this section

★ Availability of required modules

For each of the roofing types that have passed all previous tests, the availability of required modules is checked.

In the case of SYSTEMS, the suppliers database is checked. If no supplier of the building blocks exists, then you will be queried as to whether you are interested in investigating the possibility of constructing the building blocks yourself.

★ Availability of equipment, materials, tools and labour

These will be handled in much the same way as above, in that the availability of those equipment, materials, tools and labour required for each roofing type will be queried.

(v) Acceptability of roofing types

This step is done so as to find out what your own personal preference is.

All those roofing types that have passed the previous tests are now displayed on the screen. You will be asked to indicate which of these roofing types you would like to investigate further. Your **BUILDROOF VISUAL GUIDE** contains illustrations of the roofing types and plans of the different sub-units. It should therefore assist you in this step.

In the case of the units, a list of the sub-units of each units roofing type is given and you are asked to select those that you find acceptable.

SECTION B

In this part, a more detailed costing of all those roofing types that were channelled down through Section A, is undertaken. Costing of each sub-unit in the case of each UNIT roofing type and each Building block in the case of a SYSTEM roofing type is now carried out.

You will be asked for costs of services and goods required for the roofing types which you wish to investigate further. Facilities exist whereby data on the availability of goods and services and their costs can be obtained. These facilities can be accessed from the last option on the goods or services cost querying screens i.e **Don't know - more info required.** If you select this option, a screen containing details of local suppliers and their costs will be displayed. Use this info to answer the cost queries.
Answer all questions as accurately as possible.

At the end of this section all sub-units and system building blocks will have been priced.

If affordable, the individual costs of modules, equipment, materials, tools and labour are then stored ready for output.

In the case of SYSTEMS, the costs that have been calculated are per building block. Thus once again an affordable area will be proposed to you and you will be asked to either reject or accept this final proposal.

Option 2: OUTPUT BUILDROOF RUN RESULTS

This option allows you to view the final predicted costs for all the roofing types, be they sub-units or systems which passed all the BUILDROOF run sub-sections.
The total cost of each roofing type is sub-divided into the five categories i.e modules, equipment, materials, tools and labour.

Minimal input is required from you. Simply follow the basic instructions given.

Note: A run number will be issued to you for each roofing type. Please make a note of this number since it will be required for Option 5.

Option 3: CHANGE LOCATION

The location which you select is instrumental in selecting roofing types that are climatically suitable. This option (as discussed in Option 1) allows you to change these location details.

The current location will be displayed and you will be asked whether you wish to change this present location. If you select to, a list of provinces, homelands and states for which data is available will be shown. When one has been selected, the main towns / cities of that province / homeland / state will appear on the screen and you will be asked to choose the city or town closest to the location in which the house is to be built.

Option 4: INPUT OF DATA ON AVAILABILITY OF MODULES, EQUIPMENT, MATERIALS, TOOLS AND LABOUR

This option allows you access to the facilities in which suppliers of any goods or services can advertise.

You will be queried as to which of the following goods or services you wish to enter data on i.e. modules, equipment, materials, tools or labour and then more specifically the actual goods or service e.g. drilling machine from tools.

Once these nave been selected, all required information is asked of you and stored for future use.

Option 5: DATA ON ACTUAL COSTS RETURNED

By returning your data on actual costs incurred and costs predicted during the BUILDROOF run, this option updates the approximated costs and approximates miscellaneous costs, both of which will be used to improve decisions taken and predictions made in the next BUILDROOF run.

The following will be asked of you:-

- All predicted sub-costs at the time of the BUILDROOF run
- All actual sub-costs incurred during construction
- The run number issued to you with the outputting of BUILDROOF run results
- The period, in months, between the run, building dates and now.

Answer all questions as accurately as possible.

Option 6: INPUTTING A NEW ROOFING TYPE

This option allows BUILDROOF's database of roofing types to be expanded upon, thereby incorporating any roofing types (units and systems) that have not already been included as well as new roofing types that may be developed in the future. This therefore eliminates the need for the initial developer of this package to have to be called in everytime a new roofing type is to be entered.

This option should ideally be done by an 'expert' in the new roofing type. All necessary information will be asked of the expert.

APPENDIX C

BUILDROOF VISUAL GUIDE

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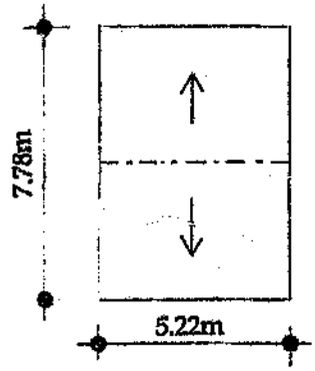
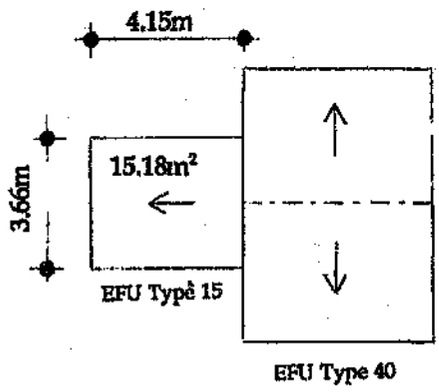
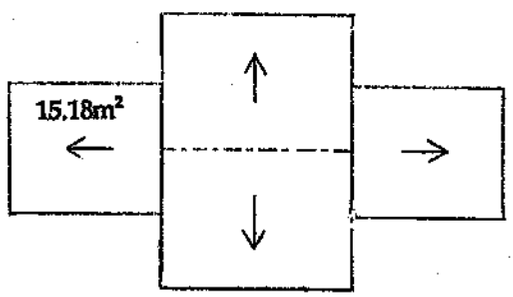
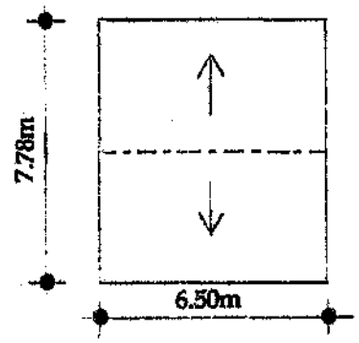
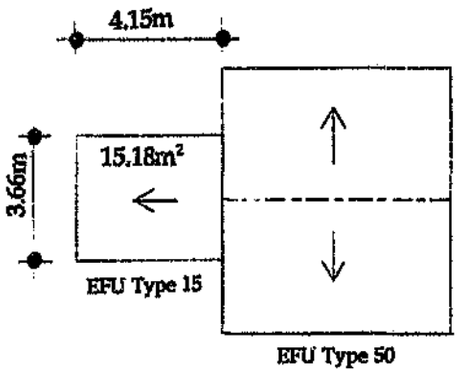
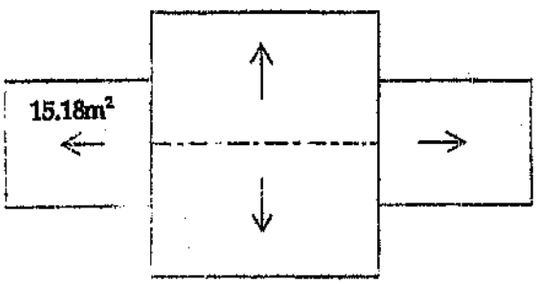
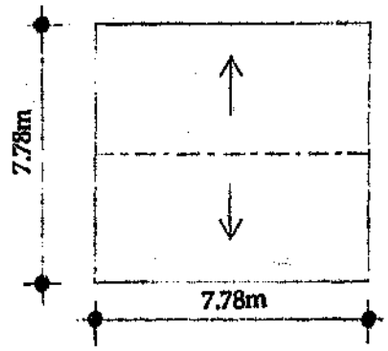
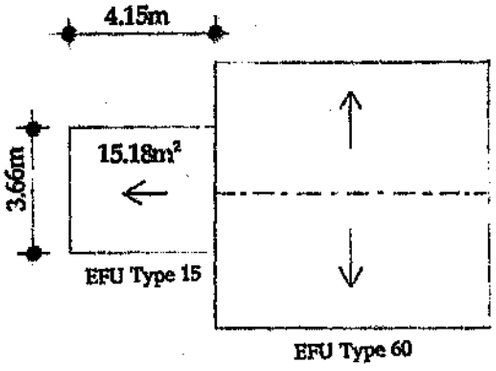
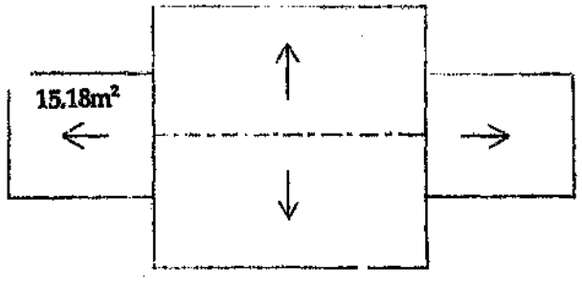
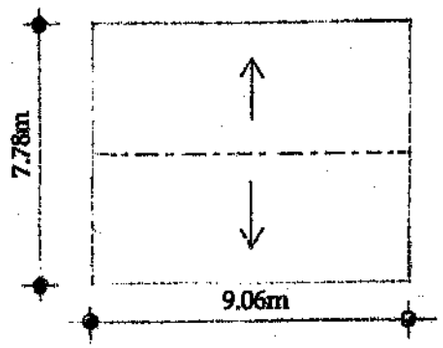
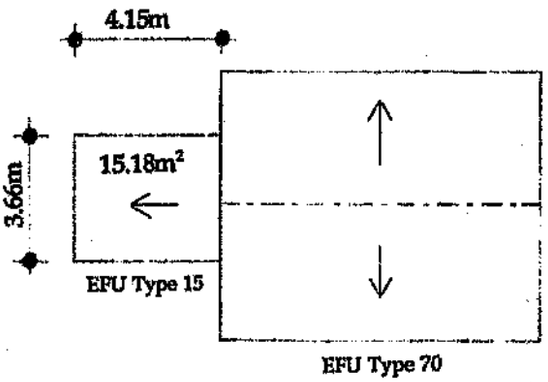
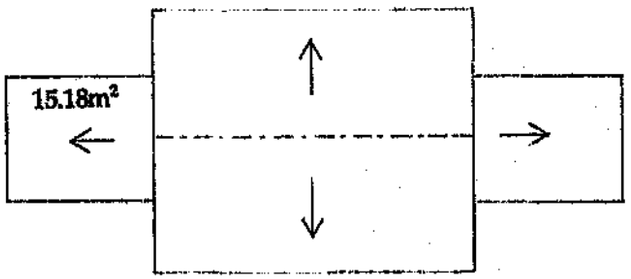
Evertile Fast-Frame Units	1-5
USSR	6-7
Concrete precast troughs	8
Concrete hollow blocks	9

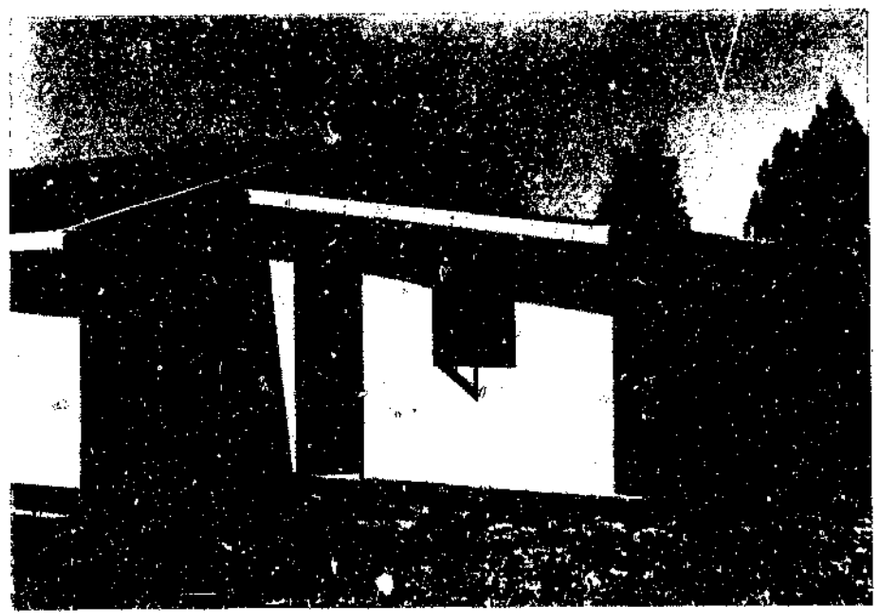
1. EVERTILE FAST-FRAME UNITS

SUB-UNIT	AREA	SHAPE
EFU T40	40.6m²	
EFU T40+T15	56.8m²	
EFU T40+2*T15	71m²	

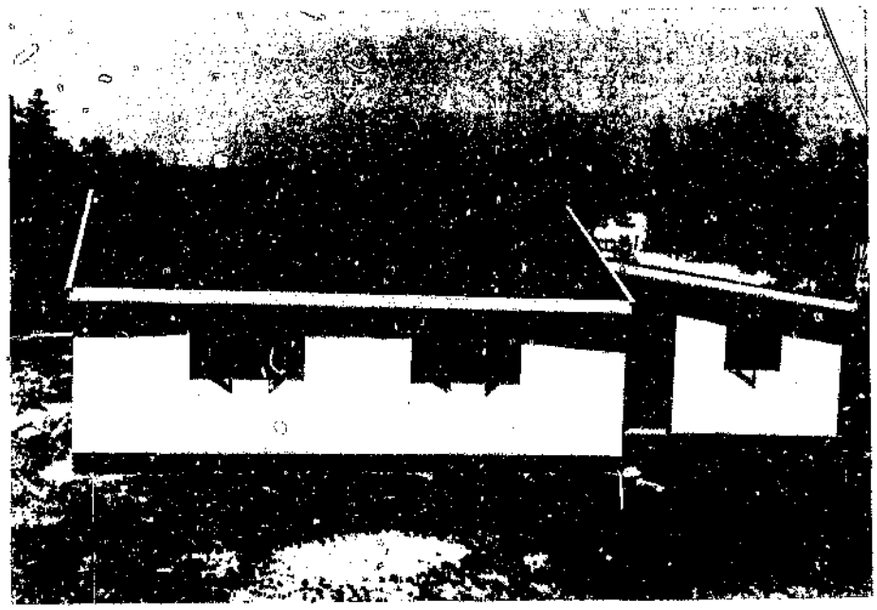
SUB-UNIT	AREA	SHAPE
EFU T50	50.6m^2	
EFU T50+T15	65.8m^2	
EFU T50+2*T15	80.9m^2	

SUB-UNIT	AREA	SHAPE
EFU T60	60.3m²	
EFU T60+T15	75.5m²	
EFU T60+2*T15	90.7m²	

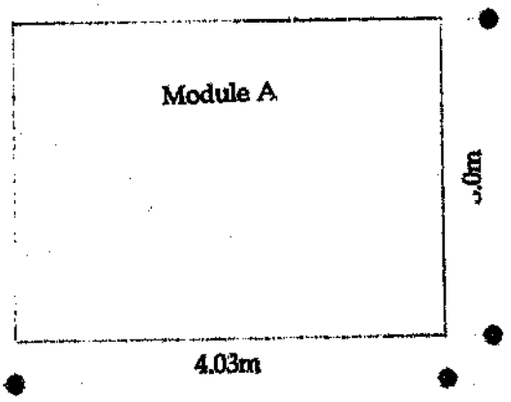
SUB-UNIT	AREA	SHAPE
EFU T70	70.5m^2	
EFU T70+T15	85.7m^2	
EFU T70+2*T15	100.8m^2	



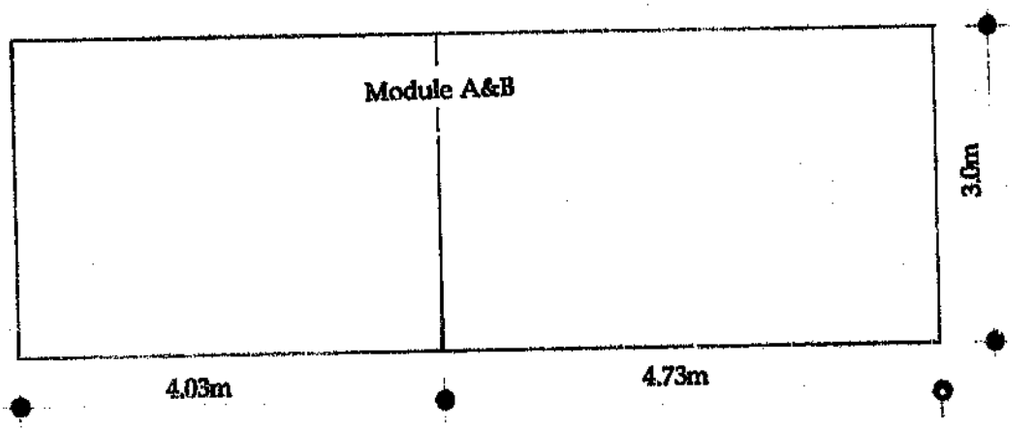
Views of the EFU T60+T15 unit



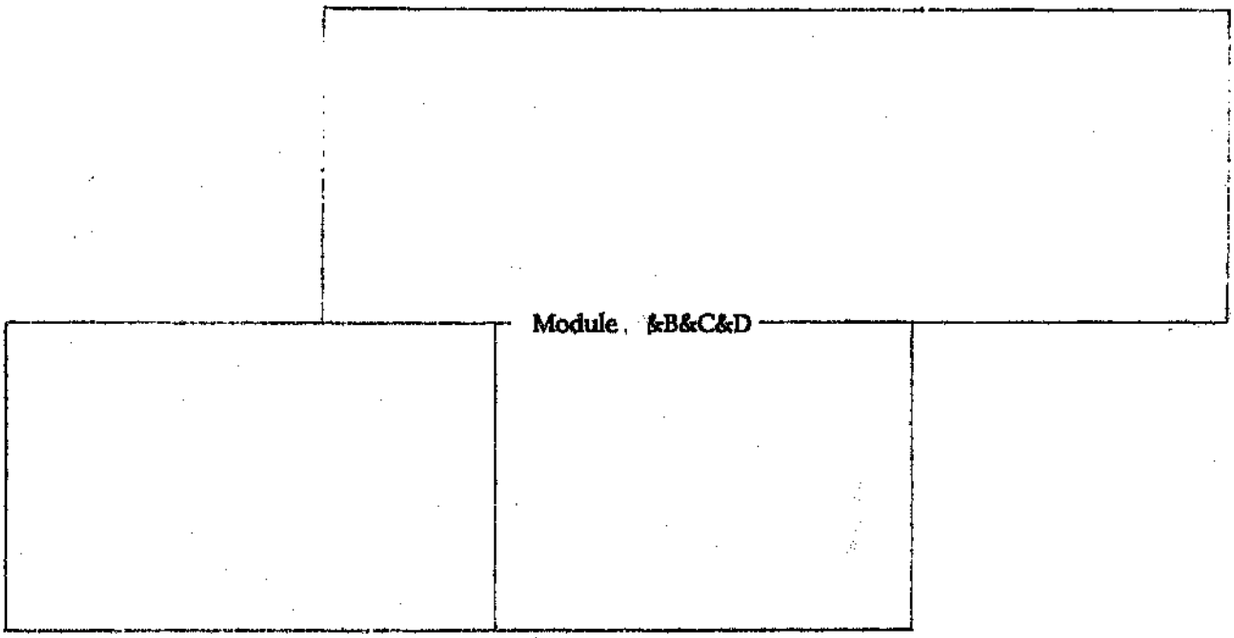
2. USSR



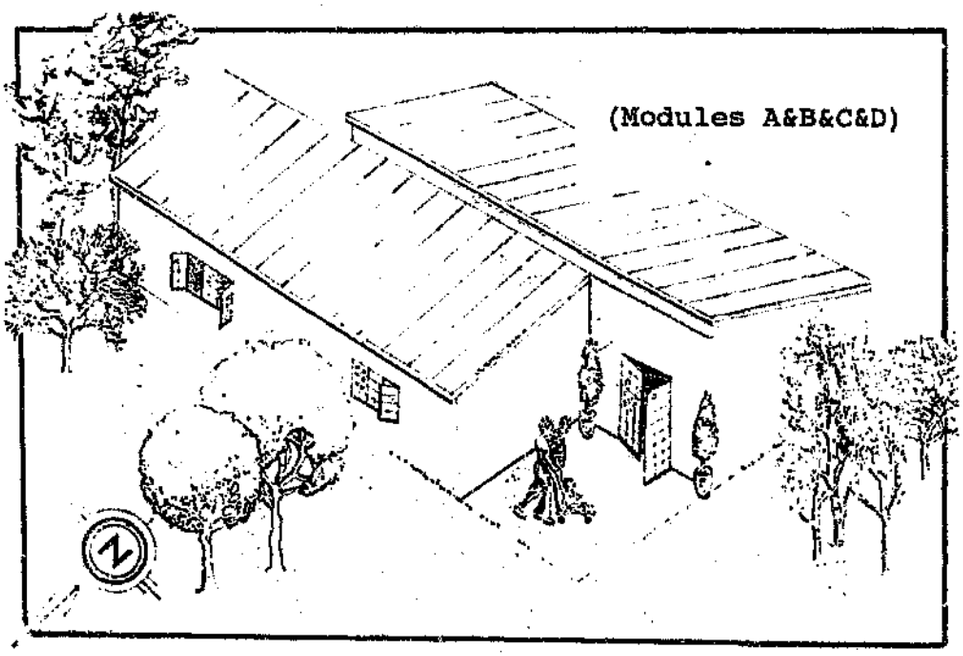
USSR 15



USSR 30



USSR 60

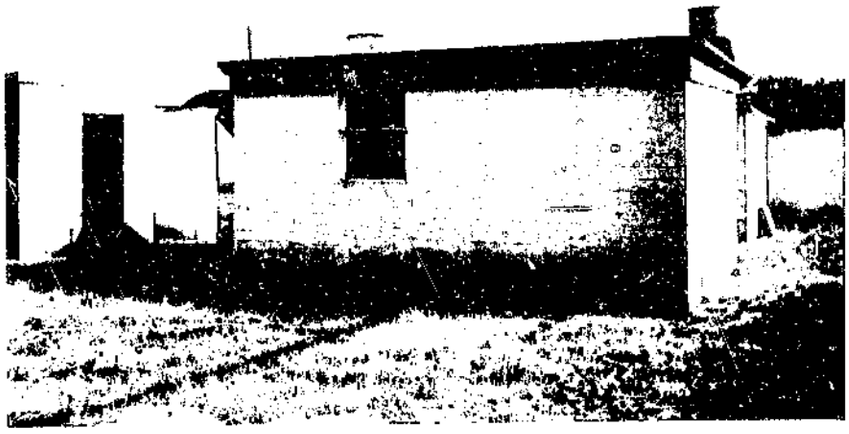


Isometric view of USSR 60

3. CONCRETE PRECAST TROUGHS



Front View

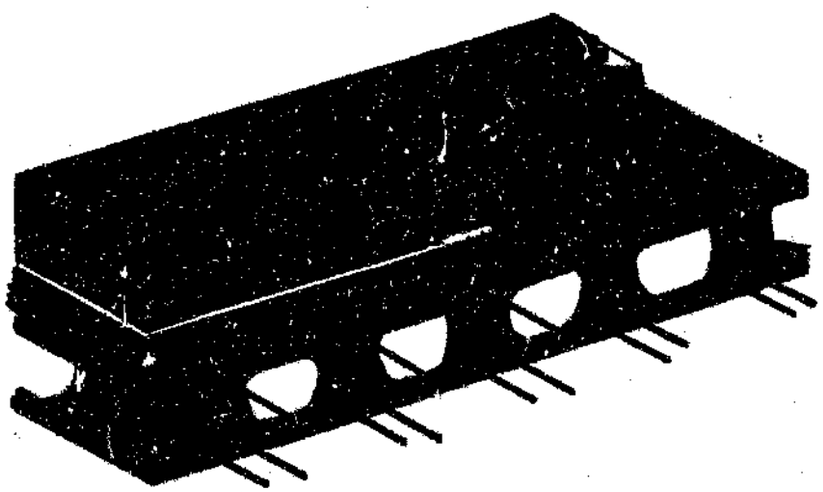


Back View



Internal View

4. CONCRETE HOLLOW BLOCKS



Isometric sketch of blocks

APPENDIX D

CLIMATIC CALCULATIONS

CLIMATIC ZONES

Table D1 shows the 12 zones into which South Africa is divided. Basically the zones are derived from Koppen's classification of climate with, however, due consideration of conventional geographical and other climatic and agricultural boundaries. [29,30]

WEATHER STATISTICS AVAILABLE

The following data, amongst other, is collected at each weather station:

* the monthly average of daily maximum temperature (A);
* the monthly average of daily minimum temperature (B) and
* monthly precipitations (C).

Values A, B and C are averaged with data from all the previous years for which data was available. These values (say A', B' and C') are documented in the WB40. [29]

METHODOLOGY IMPLEMENTED TO CALCULATE SUITABILITY OF ROOFING TYPES TO ZONES

For each weather station, the maximum A', minimum B' and sum total of all the C' values were collected for all the major weather stations of each zone.

Within each of the 12 zones, averages of all three values were calculated using data from those weather stations within the particular zone. These values formed the limit of each zone. (See table D1)

Data queried from the 'expert' of each roofing type included:

* maximum temperature for which roofing type is suited to
* minimum temperature for which roofing type is suited to and
* maximum temperature which roofing type is suited to.
  (See table D2)

These values were then compared to the limits of each zone and if they fell within those limits, then the roofing type was assumed to be suited to that zone.
(See table D3)

ZONE	REGION	TYPE OF CLIMATE	AVERAGE MAX TEMP (°C)	AVERAGE MIN TEMP (°C)	AVERAGE ANNUAL RAINFALL (mm)
W	Namaqualand and Northwestern Cape Province	Desert Climate	31.0	3.0	156
M	Southwestern Cape	Winter rainfall area; Mediterranean climate	26.2	7.6	373
K	Karoo (great and little)	Mainly Desert Climate	30.2	4.3	339
A	Southern Cape Coastal Belt	Rain during all seasons	25.6	7.8	573
SE	Southern Coastal Belt	Warm temperate with Summer rainfall maximum	26.7	7.9	786
E	Eastern Coastal Belt and Zululand	Subtropical with Summer rains	28.9	10.3	948
D	Drakensberg escarpment (interior Natal and Ka aria)	Warm temperate with Summer rainfall	26.8	1.7	926

Table D1: Details of climatic zones

ZONE	REGION	TYPE OF CLIMATE	AVERAGE MAX TEMP (°C)	AVERAGE MIN TEMP (°C)	AVERAGE ANNUAL RAINFALL (mm)
L	Lowveld (Eastern Transvaal)	Hot Steppe (Savanna) with Summer rainfall	30.4	8.0	680
NT	Northern Transvaal	Hot Steppe with Summer rainfall	29.6	4.0	548
H	Highveld (Southern Transvaal, Eastern Orange Free State and Lesotho)	Warm temperate with Summer rainfall	26.5	0.6	705
Sn	Northern Steppe (Northern Cape Province and Western Orange Free State)	Steppe, Summer and Autumn rainfall	31.3	0.9	500
Ss	Southern Steppe (Northeastern Cape Province)	Cold Steppe with Autumn rainfall maximum	29.8	-0.1	4 3

Table D1: Details of climatic zones continued

ROOFING TYPE	Max temp (°C)	Min temp (°C)	Max rainfall (mm)
USSR	40	-5	1000
EFU	38	-8	1000
Concrete troughs	35	-2	750
Concrete blocks	35	-2	750

Table D2: Roofing type climatic details

Climatic zone	USSR	EFU	Concrete troughs	Concrete blocks
W	Y	Y	Y	Y
M	Y	Y	Y	Y
K	Y	Y	Y	Y
A	Y	Y	Y	Y
SE	Y	Y	N	N
E	Y	Y	N	N
D	Y	Y	Y	Y
L	Y	Y	Y	Y
NT	Y	Y	Y	Y
H	Y	Y	Y	Y
Sn	Y	Y	Y	Y
Ss	Y	Y	Y	Y

Table D3: Roofing type suitability to climatic zones

APPENDIX E

COMMAND LANGUAGE

```
:MENU
CLS
ASK [CHOICE]
/* ########BUILDROOF##########
/*
IF [CHOICE] = 1
/* ****** Clean RS Frame ******
:CLEAN_RS_FRAME
     RULES 1/F
     IF [X] < [CURRENT_RS_NUM]
          CLEAR R 1
          CLEAR V 23
          SET [X] ([X]+1)
          GOTO CLEAN_RS_FRAME
     ENDIF
     SET [X] 1
/* ****** Checks ALL RS for climatic suit *******
     SET [X] 1
     :CLIMATE
          RULES 2/F
          IF [X] < [CURRENT_RS_NUM]
               CLEAR R 2
               CLEAR V 1
               SET [X] ([X]+1)
               GOTO CLIMATE
          ENDIF
     IF [C]=0
          CLS
          CURSET 5,10
          PRINT Unfortunately, none of the roofing types in the
          CURSET 7,10
          PRINT database are climatically suited to the location
          CURSET 9,10
          PRINT in which you plan to build.
          CURSET 11,10
          PRINT Please try running this again when a greater
          CURSET 13,10
          PRINT variety of roof types is in the database.
          CURSET 17,10
          PRINT Press any key to exit BUILDROOF
          PAUSE
          EXIT
     ENDIF
 /* ************ Checks ALL RS for extras suit *****************
:EXTRAS
RULES 24/F
      IF [COUNT] < [C]
         CLEAR R 3-24
         CLEAR R 437-439
         CLEAR V 13-19
         CLEAR V 21
         CLEAR V 77
         CLEAR V 79-84
         CLEAR V 390
         CLEAR Q 8
         SET [COUNT] ([COUNT]+1)
         GOTO EXTRAS
      ENDIF
     IF [E]=0
          CLS
          CURSET 5,10
          PRINT Unfortunately, none of the roofing types in the
          CURSET 7,10
          PRINT database meet the extras as indicated by
          yourself.
          CURSET 9,10
```

```
            PRINT Try running this program again when more types
            CURSET 11,10
            PRINT are in the database.
            CURSET 14,10
            PRINT Press any key to exit BUILDROOF
            PAUSE
            EXIT
      ENDIF
/* ************ Draft costing test ******************
SET [X] 1
:FIN_DRAFT
      IF [X]<=[E]
            RULES 27/F
            SET [X] ([X]+1)
            CLEAR R 25-27
            CLEAR R 305
            CLEAR V 24
            CLEAR V 28
            CLEAR V 49
            CLEAR V 85
            CLEAR V 87
            CLEAR V 248-253
            CLEAR Q 27
            CLEAR Q 80
            GOTO FIN_DRAFT
       ENDIF
      IF [F]=1
            CLS
            CURSET 5,10
            PRINT Unfortunately, none of the roofing types in the
            CURSET 7,10
            PRINT database meet your financial limitations.
            CURSET 9,10
            PRINT Please try running BUILDROOF again when more
            CURSET 11,10
            PRINT types are in the database.
            CURSET 14,10
            PRINT Press any key to exit BUILDROOF
            PAUSE
            EXIT
      ENDIF
/* ********** First MODULES check **************
SET [F] ([F]-1)
SET [COUNTER] 1
SET [X] 1
:MODULES_NEW_RS
      IF [X] <= [F]
            :MODULES_SET
            RULES 39-41/F
                  IF [COUNTER] < [CURRENT_RS_NUM]
                        CLEAR R 30-41
                        CLEAR V 104-107
                        CLEAR V 109
                        CLEAR V 254
                        CLEAR Q 33-36
                        CLEAR Q 81-82
                        SET [COUNTER] ([COUNTER]+1)
                        GOTO MODULES_SET
                  ENDIF
            RULES 42/F
            SET [COUNTER] 1
            SET [X] ([X]+1)
            CLEAR R 28-42
            CLEAR V 88-89
            CLEAR V 104-107
            CLEAR V 109
```

```
            CLEAR V 254
            CLEAR Q 32-36
            CLEAR Q 81-82
            GOTO MODULES_NEW_RS
        ENDIF
      IF [D]=0
            CLS
            CURSET 5,10
            PRINT Unfortunately, the modules required for
            CURSET 7,10
            PRINT the roofing types which you are investigating,
            CURSET 9,10
            PRINT are not known to be available in your area.
            CURSET 11,10
            PRINT Please try running BUILDROOF again when more
            CURSET 13,10
            PRINT data on modules availability and a greater
            CURSET 15,10
            PRINT variety of roof types is in the database.
            CURSET 18,10
            PRINT Press any key to exit BUILDROOF
            PAUSE
            EXIT
      ENDIF
/* ************** First EQUIPMENT Check ******************
SET [COUNTER] 1
SET [X] 1
       :EQUIP_NEW_RS
       IF [X] <= [D]
            :EQUIP_SET
            RULES 52-54/F
                  IF [COUNTER] < [CURRENT_EQUIP_NUM]
                        CLEAR R 45-54
                        CLEAR V 111-115
                        CLEAR V 256
                        CLEAR Q 39-42
                        SET [COUNTER] ([COUNTER]+1)
                        GOTO EQUIP_SET
                  ENDIF
            RULES 55/F
            SET [COUNTER] 1
            SET [X] ([X]+1)
            CLEAR R 43-55
            CLEAR V 101-102
            CLEAR V 111-115
            CLEAR V 255-256
            CLEAR Q 38-42
            GOTO EQUIP_NEW_RS
       ENDIF
      IF [Q]=0
            CLS
            CURSET 5,10
            PRINT Unfortunately, not all the equipment required for
            CURSET 7,10
            PRINT the roofing types which you are investigating,
            CURSET 9,10
            PRINT is known to be available in your area.
            CURSET 11,10
            PRINT Please try running BUILDROOF again when more
            CURSET 13,10
            PRINT data on equipment availability and a greater
            CURSET 15,10
            PRINT variety of roof types is in the database.
            CURSET 18,10
            PRINT Press any key to exit BUILDROOF
            PAUSE
```

```
            EXIT
        ENDIF
/* ************ First MATERIALS Check**************************
SET [COUNTER] 1
SET [X] 1
        :MATERIALS_NEW_RS
        IF [X] <= [Q]
            :MATERIALS_SET
            RULES 65-67/F
                IF [COUNTER] < [CURRENT_MAT_NUM]
                    CLEAR R 58-67
                    CLEAR V 92-94
                    CLEAR V 97-98
                    CLEAR V 257
                    CLEAR Q 28-31
                    SET [COUNTER] ([COUNTER]+1)
                    GOTO MATERIALS_SET
                ENDIF
            RULES 68/F
            SET [COUNTER] 1
            SET [X] ([X]+1)
            CLEAR R 56-68
            CLEAR V 125-126
            CLEAR V 257-258
            CLEAR V 92-94
            CLEAR V 97-98
            CLEAR Q 28-31
            CLEAR Q 37
            GOTO MATERIALS_NEW_RS
    ENDIF
     IF [M]=0
          CLS
          CURSET 5,10
          PRINT Unfortunately, not all the materials required for
          CURSET 7,10
          PRINT the roofing types which you are investigating,
          CURSET 9,10
          PRINT are known to be available in your area.
          CURSET 11,10
          PRINT Please try running BUILDROOF again when more
          CURSET 13,10
          PRINT data on materials availability and a greater
          CURSET 15,10
          PRINT variety of roof types is in the database.
          CURSET 18,10
          PRINT Press any key to exit BUILDROOF
          PAUSE
          EXIT
     ENDIF
/* ********** First TOOLS Check ******************************
SET [COUNTER] 1
SET [X] 1
        :TOOLS_NEW_RS
        IF [X] <= [M]
             :TOOLS_SET
             RULES 78-80/F
                  IF [COUNTER] < [CURRENT_TOOL_NUM]
                       CLEAR R 71-80
                       CLEAR V 26-27
                       CLEAR V 41
                       CLEAR V 90-91
                       CLEAR V 99
                       CLEAR Q 10-13
                       SET [COUNTER] ([COUNTER]+1)
                       GOTO TOOLS_SET
                  ENDIF
```

```
                RULES 81/F
                SET [COUNTER] 1
                SET [X] ([X]+1)
                CLEAR R 69-81
                CLEAR V 26-27
                CLEAR V 41
                CLEAR V 90-91
                CLEAR V 99
                CLEAR V 100
                CLEAR V 103
                CLEAR V 262
                CLEAR Q 9-13
                GOTO TOOLS_NEW_RS
          ENDIF
          IF [T]=0
               CLS
               CURSET 5,10
               PRINT Unfortunately, not all the tools required for
               CURSET 7,10
               PRINT the roofing types which you are investigating,
               CURSET 9,10
               PRINT are known to be available in your area.
               CURSET 11,10
               PRINT Please try running BUILDROOF again when more
               CURSET 13,10
               PRINT data on tools availability and a greater
               CURSET 15,10
               PRINT variety of roof types is in the database.
               CURSET 18,10
               PRINT Press any key to exit BUILDROOF
               PAUSE
               EXIT
          ENDIF
/* ********** First LABOUR Check **********************
SET [COUNTER] 1
SET [X] 1
          :LABOUR_NEW_RS
          IF [X] <= [T]
               :LABOUR_SET
               RULES 91-93/F
                    IF [COUNTER] < [CURRENT_LAB_NUM]
                                        CLEAR R 84-93
                                        CLEAR V 120-124
                                        CLEAR V 260
                                        CLEAR Q 44-47
                                        SET [COUNTER] ([COUNTER]+1)
                                        GOTO LABOUR_SET
                    ENDIF
               RULES 94/F
               SET [COUNTER] 1
               SET [X] ([X]+1)
               CLEAR R 82-94
               CLEAR V 116-117
               CLEAR V 120-124
               CLEAR V 259-260
               CLEAR Q 43-47
               GOTO LABOUR_NEW_RS
          ENDIF
          IF [L]=0
               CLS
               CURSET 5,10
               PRINT Unfortunately, not all the skills required for
               CURSET 7,10
               PRINT the roofing types which you are investigating,
               CURSET 9,10
               PRINT are known to be available in your area.
```

```
            CURSET 11,10
            PRINT Please try running BUILDROOF again when more
            CURSET 13,10
            PRINT data on skills availability and a greater
            CURSET 15,10
            PRINT variety of roof types is in the database.
            CURSET 18,10
            PRINT Press any key to exit BUILDROOF
            PAUSE
            EXIT
      ENDIF
/* ******************************************************
SET [COUNT] 1
:ACCEPT
RULES 105-114/F
      IF [COUNT] < [L]
            CLEAR R 105-114
            SET [COUNT] ([COUNT]+1)
            GOTO ACCEPT
       ENDIF
      IF [A]=0
            CLS
            CURSET 5,10
            PRINT Unfortunately, none of the roofing types which
            CURSET 5,10
            PRINT we have been investigating, and which suit your
            CURSET 5,10
            PRINT climatic, financial and extras criteria are
            CURSET 5,10
            PRINT acceptable to you.
            CURSET 5,10
            PRINT Please try running BUILDROOF again when a greater
            CURSET 5,10
            PRINT variety of roof types is in the database.
            CURSET 5,10
            PRINT
            CURSET 5,10
            PRINT Press any key to exit BUILDROOF
            PAUSE
            EXIT
      ENDIF
/* ******************************************************
SET [X] 1
:COSTING
SET [COUNTER] 1
IF [X] <= [A]
      RULES 115/F
      IF [TYPE]=1
            SET [U] [FIRST SU]
            GOTO UNITS
      ELSE
            GOTO SYSTEMS
      ENDIF
      :UNITS
      :SUB_UNITS_ACCEPT
            IF [U] <= ([FIRST SU]+14)
                  RULES 116-151/F
                  SET [COUNTER] ([COUNTER]+1)
                  SET [U] ([U]+1)
                  CLEAR R 116-151
                  CLEAR V 51-53
                  CLEAR Q 16
                  GOTO SUB_UNITS_ACCEPT
            ENDIF
      RULES 152-166/F
      SET [U] [FIRST SU]
```

```
            :COST_SUB_UNITS
                 IF [U] <= [LAST SU]
                                        IF [INVESTIGATE SU] = 0
                                                SET [U] ([U]+1)
                                                CLEAR V 76
                                                GOTO COST_SUB_UNITS
                                        ENDIF
                                        SET [COUNT] 1
/* ********************************************
            :SYSTEMS
                                                :MODULE_COSTING
                                        I F     [ C O U N T ]     < =
[CURRENT_MOD_NUM]
                                                                  R U L E S
184-192/F
                                                                  IF [OO]=1
                                                                  R U L E S
193-197/F
                                                                  ENDIF
                                                                  R U L E S
198/F
                                                                  CLEAR  R
184-198
                                                                  CLEAR  V
159-163
                                                                  CLEAR  V
165
                                                                  CLEAR  V
266
                                                                  CLEAR  Q
53-57
                                                                  SET [OO]
0
                                                                  G O T O
MODULE_COSTING
                                                        ENDIF
                                                        RULES 199-204/F
                                                        SET [COUNT] 1
/* ********************************************
                                        :EQUIPMENT_COSTING
                                                IF      [COUNT]     <=
[CURRENT_EQUIP_NUM]
                                                                  R U L E S
205-217/F
                                                                  IF [EE]=1
                                                                  R U L E S
218-226/F
                                                                  ENDIF
                                                                  R U L E S
227/F
                                                                  CLEAR  R
205-227
                                                                  CLEAR  V
166-174
                                                                  CLEAR  V
176-178
                                                                  CLEAR  V
267-269
                                                                  CLEAR  Q
58-63
                                                                  SET [EE]
0
                                                                  G O T O
EQUIPMENT_COSTING
```

```
                                                    ENDIF
                                                    RULES 228-229/F
                                                    SET [COUNT] 1
/* ********************************************
                                        :MATERIAL_COSTING
                                                    IF    [COUNT]    <=
[CURRENT_MAT_NUM]
                                                          R U L E S
167-175/F
                                                          IF [MM]=1
                                                          R U L E S
176-180/F
                                                          ENDIF
                                                          R U L E S
181/F
                                                          CLEAR  R
167-181
                                                          CLEAR  V
151-155
                                                          CLEAR  V
157-158
                                                          CLEAR  V
263
                                                          CLEAR  Q
48-52
                                                          SET [MM]
0
                                                          G O T O
MATERIAL_COSTING
                                                    ENDIF
                                                    RULES 182-183/F
                                                    SET [COUNT] 1
/* ********************************************
                                        :TOOL_COSTING
                                                    IF    [COUNT]    <=
[CURRENT_TOOL_NUM]
                                                          R U L E S
230-242/F
                                                          IF [TT]=1
                                                          R U L E S
243-251/F
                                                          ENDIF
                                                          R U L E S
252/F
                                                          CLEAR  R
230-252
                                                          CLEAR  V
63-69
                                                          CLEAR  V
71-75
                                                          CLEAR  V
150
                                                          CLEAR  V
270-272
                                                          SET [TT]
0
                                                          CLEAR  Q
17-22
                                                          G O T O
TOOL_COSTING
                                                    ENDIF
                                                    RULES 253-254/F
                                                    SET [COUNT] 1
/* ********************************************
                                :LAB_COSTING
```

```
                                                    IF    [COUNT]    <=
[CURRENT_LAB_NUM]
                                                         R U L E S
255-265/F
                                                         IF [LL]=1
                                                         R U L E S
266-272/F
                                                         ENDIF
                                                         R U L E S
273/F
                                                         CLEAR  R
255-273
                                                         CLEAR  V
179-186
                                                         CLEAR  V
188-189
                                                         CLEAR  V
273-275
                                                         CLEAR  Q
64-69
                                                         SET [LL]
0
                                                         G O T O
LAB_COSTING
                                                    ENDIF
                                                    RULES 274-275/F
/* ****************************************
                                          RULES 276-278/F
                                          SET [MAT COST] 0
                                          SET [MOD COST] 0
                                          SET [TOOL COST] 0
                                          SET [EQUIP COST] 0
                                          SET [LAB COST] 0
                                          SET [MAT COST FCD] 0
                                          SET [MOD COST FCD] 0
                                          SET [TOOL COST FCD] 0
                                          SET [EQUIP COST FCD] 0
                                          SET [LAB COST FCD] 0
                                          SET [TOTAL COST] 0
                                          CLEAR R 115-278
                                          CLEAR V 63-69
                                          CLEAR V 71-76
                                          CLEAR V  .C 155
                                          CLEAR V  .  -163
                                          CLEAR V 165-174
                                          CLEAR V 176-186
                                          CLEAR V 188-190
                                          CLEAR V 195
                                          SET [MM] 0
                                          SET [OO] 0
                                          SET [TT] 0
                                          SET [EE] 0
                                          SET [LL] 0
                                          CLEAR Q 17-22
                                          CLEAR Q 48-69
                                          IF [TYPE]=0
                                                    GOTO HERE
                                          ENDIF
                                          SET [U] ([U]+1)
                                          GOTO COST_SUB_UNITS
                    ENDIF
          :HERE
          CLEAR R 115-278
          CLEAR R 479
          CLEAR Q 14
          CLEAR Q 16
```

```
        CLEAR Q 17-22
        CLEAR Q 118
        CLEAR V 39
        CLEAR V 42-49
        CLEAR V 51-76
        CLEAR V 129-149
        CLEAR V 263-275
        CLEAR V 479-488
        CLEAR V 503-507
        CLEAR V 556-559
        SET [X] ([X]+1)
        GOTO COSTING
ENDIF
CLS
CURSET 5,10
PRINT BUILDROOF run complete.
CURSET 8,10
PRINT To view results, select option 2 of the BUILDROOF menu
CURSET 13,10
PRINT Press any key to return to the BUILDROOF menu
PAUSE
GOTO MENU
ENDIF
/* ############### OUTPUT DATA ######################
IF [CHOICE]=2
        SET [SYS] 1
        :SYSTEMS_OUTPUT
                IF [SYS] <= [SYS_NUMBERS]
                        RULES 440-441/F
                        CLEAR R 440-441
                        CLEAR V 511-513
                        CLEAR V 515-525
                        CLEAR Q 116
                        SET [SYS] ([SYS]+1)
                        GOTO SYSTEMS_OUTPUT
                ENDIF
        SET [UN] 1
        :UNITS_OUTPUT
                IF [UN] <= [UN_NUMBERS]
                        RULES 442/F
                        CLEAR R 442
                        CLEAR V 529-541
                        CLEAR Q 117
                        SET [UN] ([UN]+1)
                        GOTO UNITS_OUTPUT
                ENDIF
        CLS
        CURSET 5,10
        PRINT Output of results completed
        CURSET 15,10
        PRINT Please be patient for a few minutes. The data-bases
        CURSET 17,10
        PRINT are being prepared for the next run of BUILDROOF.
/* ******** CLEANS FRAMES **********************
SET [X] 1
/*
:CLEAN_SUPPLIER
        RULES 443/F
        IF [X] < [CURRENT_RS_NUM]
                CLEAR R 443
                CLEAR V 542
                SET [X] ([X]+1)
                GOTO CLEAN_SUPPLIER
        ENDIF
        SET [X] 1
/*
```

```
:CLEAN_MD_EUINF
      RULES 474/F
      IF [X] < [CURRENT_MOD_NUM]
            CLEAR R 474
            CLEAR V 542
            SET [X] ([X]+1)
            GOTO CLEAN_MD_EUINF
      ENDIF
      SET [X] 1
/*
:CLEAN_EQ_EUINF
      RULES 475/F
      IF [X] < [CURRENT_EQUIP_NUM]
            CLEAR R 475
            CLEAR V 542
            SET [X] ([X]+1)
            GOTO CLEAN_EQ_EUINF
      ENDIF
      SET [X] 1
/*
:CLEAN_MT_EUINF
      RULES 476/F
      IF [X] < [CURRENT_MAT_NUM]
            CLEAR R 476
            CLEAR V 542
            SET [X] ([X]+1)
            GOTO CLEAN_MT_EUINF
      ENDIF
      SET [X] 1
/*
:CLEAN_TL_EUINF
      RULES 477/F
      IF [X] < [CURRENT_TOOL_NUM]
            CLEAR R 477
            CLEAR V 542
            SET [X] ([X]+1)
            GOTO CLEAN_TL_EUINF
      ENDIF
      SET [X] 1
/*
:CLEAN_LB_EUINF
      RULES 478/F
      IF [X] < [CURRENT_LAB_NUM]
            CLEAR R 478
            CLEAR V 542
            SET [X] ([X]+1)
            GOTO CLEAN_LB_EUINF
      ENDIF
      SET [X] 1
CLS
CURSET 15,15
PRINT Thank-you. Please press any key to return to the menu
PAUSE
GOTO MENU
ENDIF
/*
/* ################ CHANGE LOCATION ##########################
IF [CHOICE]=3
      ASK [CHANGE_LOC]
      IF [CHANGE_LOC]="N"
            GOTO MENU
      ENDIF
      IF [CHANGE_LOC]="n"
            GOTO MENU
      ENDIF
      IF [CHANGE_LOC]="Y"
```

```
            :YES
            CLS
            RULES 296-303/F
            WHILE [NUM]<=[CURRENT_RS_NUM]
                  RULES 304/F
                  SET [NUM] ([NUM]+1)
                  CLEAR R 304
                  CLEAR [CLIM_SUIT]
            WEND
            CLS
            CURSET 8,19
            PRINT Reset of location details complete
            CURSET 15,15
            PRINT Press any key to return to BUILDROOF MENU
            PAUSE
            GOTO MENU
      ENDIF
      IF [CHANGE_LOC]="y"
            GOTO YES
      ENDIF
ENDIF
/* ################ ENTER INFO ####################
IF [CHOICE]=4
      RULES 279-295/F
      GOTO MENU
ENDIF
/* ################ ENTER RS FACTOR INFO ####################
IF [CHOICE]=5
      CLS
      CURSET 10,8
      PRINT Thank you for returning the data on ACTUAL costs
      CURSET 12,12
      PRINT incurred as apposed to QUOTED costs
      CURSET 18,12
      PRINT Please press any key to commence
      PAUSE
      ASK V 358
      RULES 327-330/F
/*       RESULTS
      GOTO MENU
ENDIF
/* ############## INPUT A NEW RS ####################
IF [CHOICE]=6
      CLS
      ASK [NRS_NAME]
      RULES 332-333/F
      RULES 334-348/F
      RULES 479/F
/*       %%%%%% CLIM %%%%%%%
      WHILE [NRS_CLIM_COUNTER] <= 12
            RULES 3317/F
            SET [NRS_CLIM_COUNTER] ([NRS_CLIM_COUNTER]+1)
            CLEAR R 331
            CLEAR [MIN_TEMP]
            CLEAR [MAX_TEMP]
            CLEAR [MAX_RAIN]
      WEND
      RULES 436/F
      IF [E]=1
            WHILE [SU_COUNTER] <= [NRS_SU_NO]
                  RULES 349-355/F
                  SET [SU_COUNTER] ([SU_COUNTER]+1)
                  CLEAR R 349-355
                  CLEAR V 398
                  CLEAR V 403-406
            WEND
```

```
          WHILE [BB_COUNTER] <= [NRS_BB_NO]
               RULES 356/F
               SET [C] [START]
                                        W H I L E    [ C ]    < =
([LAST_FINISH]+[NRS_SU_NO])
                                                  RULES 357/F
                                                  CLEAR R 357
                                                  CLEAR V 407
                                                  CLEAR V 409
                                                  SET [C] ([C]+1)
                                        WEND
               CLEAR R 356-357
               CLEAR V 399
               CLEAR V 407
               CLEAR V 409
               SET [BB_COUNTER] ([BB_COUNTER]+1)
          WEND
     ENDIF
/*        check eq,mat,tl and lab, add new, enter data
     :NRS_EQUIP
          RULES 377-378/F
          IF [NRS_ADD_EQUIP]="Y"
               CLEAR R 370-378
               CLEAR V 119
               CLEAR V 306-312
               CLEAR V 412-413
               CLEAR Q 98-99
               GOTO NRS_EQUIP
          ENDIF
          SET [COUNTER] 1
          IF [E]=2
               GOTO EQUIPY
          ENDIF
     :NRS_EQUIP_DATA
          SET [C] [START]
          WHILE [C] <= ([LAST_FINISH]+[NRS_SU_NO])
               :EQUIPY
               IF [COUNTER] <= [EQUIP_NUM]
                                        RULES 406-413/F
                                        CLEAR R 406-413
                                        CLEAR V 115
                                        CLEAR V 421-423
                                        CLEAR V 431-436
                                        CLEAR Q 105
                                        CLEAR Q 108-109
                                        GOTO EQUIPY
               ENDIF
               SET [COUNTER] 1
               IF [E]=2
                                        GOTO NRS_MATERIALS
               ENDIF
               SET [C] ([C]+1)
               CLEAR V 409
          WEND
     :NRS_MATERIALS
          RULES 394-395/F
          IF [NRS_ADD_MAT]="Y"
               CLEAR R 379-395
               CLEAR V 95
               CLEAR V 276-285
               CLEAR V 414-415
               CLEAR V 428
               CLEAR V 489-493
               CLEAR Q 100-101
               GOTO NRS_MATERIALS
          ENDIF
```

```
     IF [E]=2
          GOTO MATY
     ENDIF
:NRS_MAT_DATA
SET [C] [START]
     WHILE [C] <= ([LAST_FINISH]+[NRS_SU_NO])
          :MATY
          IF [COUNTER] <= [MAT_NUM]
                                   RULES 414-418/F
                                   CLEAR R 414-418
                                   CLEAR V 97
                                   CLEAR V 427
                                   CLEAR V 429
                                   CLEAR V 449-450
                                   CLEAR Q 107
                                   CLEAR Q 110-111
                                   GOTO MATY
          ENDIF
          SET [COUNTER] 1
          IF [E]=2
                                   GOTO NRS_TOOLS
          ENDIF
          SET [C] ([C]+1)
          CLEAR V 409
     WEND
:NRS_TOOLS
     RULES 368-369/F
     IF [NRS_ADD_TOOL]="Y"
          CLEAR R 358-369
          CLEAR V 25
          CLEAR V 199-206
          CLEAR V 410-411
          CLEAR V 508-509
          CLEAR Q 96-97
          GOTO NRS_TOOLS
     ENDIF
     IF [E]=2
          GOTO TOOLY
     ENDIF
:NRS_TOOL_DATA
     SET [C] [START]
     WHILE [C] <= ([LAST_FINISH]+[NRS_SU_NO])
          :TOOLY
          IF [COUNTER] <= [TOOL_NUM]
                                   RULES 419-426/F
                                   CLEAR R 419-426
                                   CLEAR V 41
                                   CLEAR V 418-420
                                   CLEAR V 437-442
                                   CLEAR Q 104
                                   CLEAR Q 112-113
                                   GOTO TOOLY
          ENDIF
          SET [COUNTER] 1
          IF [E]=2
                                   GOTO NRS_LABOUR
          ENDIF
          SET [C] ([C]+1)
          CLEAR V 409
     WEND
:NRS_LABOUR
     RULES 404-405/F
     IF [NRS_ADD_LAB]="Y"
          CLEAR R 396-405
          CLEAR V 128
          CLEAR V 296-305
```

```
                    CLEAR V 416-417
                    CLEAR Q 102-103
                    GOTO NRS_LABOUR
               ENDIF
               IF [E]=2
                    GOTO LABY
               ENDIF
          :NRS_LAB_DATA
               SET [C] [START]
               WHILE [C] <= ([LAST_FINISH]+[NRS_SU_NO])
                    :LABY
                    IF [COUNTER] <= [LAB_NUM]
                                        RULES 427-434/F
                                        CLEAR R 427-434
                                        CLEAR V 124
                                        CLEAR V 424-426
                                        CLEAR V 443-448
                                        CLEAR Q 106
                                        CLEAR Q 114-115
                                        GOTO LABY
                    ENDIF
                    SET [COUNTER] 1
                    IF [E]=2
                                        GOTO HERE
                    ENDIF
                    SET [C] ([C]+1)
                    CLEAR V 409

                    435/F

               PRINT Entry of data on new RS is complete
               PAUSE
               GOTO MENU
ENDIF
/* ############## EXIT TO DOS ########################
IF [CHOICE]=7
     BEEP
     EXIT
ENDIF
DONE
```

RULES

Subject:
BUILDROOF - An expert system for selecting roofing types in developing
areas

Author:
Silvia Oliveira

Starting text:
BUILDROOF is an expert system designed to guide and advice you in
selecting a roofing type which is best suited to your needs, wants and
limitations.

This process involves an investigation of your location, extra features
wanted, the availability of goods and services to you and finally
affordability and acceptability to you.

In order to run BUILDROOF, select option #1 from the BUILDROOF MENU.

Press <ENTER> to continue

Ending text:
end

Stops afte- first successful rule in data derivations.

Probability System: 0 - 10

DISPLAY THRESHOLD: 1

```
RULES:


----------------------------------------
RULE NUMBER: 1
IF:
        [CLIMO]=1

THEN:
        FRAME("RS", #RS#=[X], #CLIM#:=0)
  and   FRAME("RS", #RS#=[X], #EXTRAS#:=0)
  and   FRAME("RS", #RS#=[X], #MATS#:=0)
  and   FRAME("RS", #RS#=[X], #TOOLS#:=0)
  and   FRAME("RS", #RS#=[X], #EQUIP#:=0)
  and   FRAME("RS", #RS#=[X], #LABOUR#:=0)
  and   FRAME("RS", #RS#=[X], #FIN#:=0)
  and   FRAME("RS", #RS#=[X], #ACCEPT#:=0)

ELSE:
        FRAME("RS", #RS#=[X], #EXTRAS#:=0)
  and   FRAME("RS", #RS#=[X], #MATS#:=0)
  and   FRAME("RS", #RS#=[X], #TOOLS#:=0)
  and   FRAME("RS", #RS#=[X], #EQUIP#:=0)
  and   FRAME("RS", #RS#=[X], #LABOUR#:=0)
  and   FRAME("RS", #RS#=[X], #FIN#:=0)
  and   FRAME("RS", #RS#=[X], #ACCEPT#:=0)
----------------------------------------
RULE NUMBER: 2
IF:
        [CLI_SUIT]="Yes"

THEN:
        [C] IS GIVEN THE VALUE [C]+1
  and   FRAME("RS", #RS#=[X], #CLIM#:=[C])
  and   FRAME("NUMBERS.FRM", $ITEM$="Clim_chg", #NUM#:=0)

ELSE:
        RT is not climatically suitable
  and   FRAME("NUMBERS.FRM", $ITEM$:="Clim_chg", #NUM#:=0)
----------------------------------------
RULE NUMBER: 3
IF:
        Have your walls already been built? Yes
  and   [WALLS_BUILT]="No"

THEN:
        Extras are not met
----------------------------------------
RULE NUMBER: 4
IF:
        Have your walls already been built? Yes
  and   [SPAN_ACT]>[SPAN_ALLOW]

THEN:
        Extras are not met
----------------------------------------
RULE NUMBER: 5
IF:
        Have your walls already been built? Yes
  and   What WALLING MATERIAL has been used? concrete blocks
  and   [WALL_CONCRETE]="No"

THEN:
        Extras are not met
```

```
RULE NUMBER: 6
IF:
        Have your walls already been built? Yes
  and   What WALLING MATERIAL has been used? bricks
  and   [WALL_BRICKS]="No"

THEN:
        Extras are not met
----------------------------------------
RULE NUMBER: 7
IF:
        Have your walls already been built? Yes
  and   What WALLING MATERIAL has been used? sheeting, cardboard
etc.
  and   [WALL_SHEETS]="No"

THEN:
        Extras are not met
----------------------------------------
RULE NUMBER: 8
IF:
        Have your walls already been built? No
  and   Do you have a specific breadth and length that you want
for your home?
        Yes
  and   [SPAN_WANT]>[SPAN_ALLOW]

THEN:
        Extras are not met
----------------------------------------
RULE NUMBER: 9
IF:
        Have your walls already been built? No
  and   What WALLING material are you planning to use? Concrete
blocks
  and   [WALL_CONCRETE]="No"

THEN:
        Extras are not met
----------------------------------------
RULE NUMBER: 10
IF:
        Have your walls already been built? No
  and   What WALLING material are you planning to use? Bricks
  and   [WALL_BRICKS]="No"

THEN:
        Extras are not met
----------------------------------------
RULE NUMBER: 11
IF:
        Have your walls already been built? No
  and   What WALLING material are you planning to use? Sheeting,
cardboard etc.
  and   [WALL_SHEETS]="No"

THEN:
        Extras are not met
----------------------------------------
RULE NUMBER: 12
IF:
        Which PITCH would you like for your roofing type? Mono
pitch
  and   Which PITCH would you like for your roofing type? NOT
Double pitch
  and   Which PITCH would you like for your roofing type? NOT
```

```
Other
  and  Which PITCH would you like for your roofing type? NOT Any
of the above
  and  [PITCH_MONO]="No"

THEN:
       Extras are not met
-----------------------------------------
RULE NUMBER: 13
IF:
       Which PITCH would you like for your roofing type? Double
pitch
  and  Which PITCH would you like for your roofing type? NOT Mono
pitch
  and   Which PITCH would you like for your roofing type? NOT
Other
  and  Which PITCH would you like for your roofing type? NOT Any
of the above
  and  [PITCH_DBL]="No"

THEN:
       Extras are not met
-----------------------------------------
RULE NUMBER: 14
IF:
       Which PITCH would you like for your roofing type? Other
  and  Which PITCH would you like for your roofing type? NOT Mono
pitch
  and   Which PITCH would you like for your roofing type? NOT
Double pitch
  and  Which PITCH would you like for your roofing type? NOT Any
of the above
  and  [PITCH_OTHER]="No"

THEN:
       Extras are not met
-----------------------------------------
RULE NUMBER: 15
IF:
       Which PITCH would you like for your roofing type? Mono
pitch OR Double
       pitch
  and   Which PITCH would you like for your roofing type? NOT
Other
  and  Which PITCH would you like for your roofing type? NOT Any
of the above
  and  [PITCH_MONO]="No"
  and  [PITCH_DBL]="No"

THEN:
       Extras are not met
-----------------------------------------
RULE NUMBER: 16
IF:
       Which PITCH would you like for your roofing type? Mono
pitch OR Other
  and   Which PITCH would you like for your roofing type? NOT
Double pitch
  and  Which PITCH would you like for your roofing type? NOT Any
of the above
  and  [PITCH_MONO]="No"
  and  [PITCH_OTHER]="No"

THEN:
       Extras are not met
```

```
RULE NUMBER: 17
IF:
       Which PITCH would you like for your roofing type? Double
pitch OR Other
  and  Which PITCH would you like for your roofing type? NOT Mono
pitch
  and  Which PITCH would you like for your roofing type? NOT Any
of the above
  and  [PITCH_DBL]="No"
  and  [PITCH_OTHER]="No"

THEN:
       Extras are not met
----------------------------------------
RULE NUMBER: 18
IF:
       Is a CEILING or potential therefore necessary? Yes
  and  [CEILING]="No"
  and  [CEILING_FAC]="No"

THEN:
       Extras are not met
----------------------------------------
RULE NUMBER: 19
IF:
       Are GUTTERS or potential therefore necessary? Yes
  and  [GUTTERS_INCL]="No"
  and  [GUTTERS_FAC]="No"

THEN:
       Extras are not met
----------------------------------------
RULE NUMBER: 20
IF:
       Is the roofing type wanted as ^^TEMPORARY HOUSING^^? Yes
  and  [TEMPORARY]="No"

THEN:
       Extras are not met
----------------------------------------
RULE NUMBER: 21
IF:
       Must the roofing type be suitable for EXTENSIONS at a
later stage? Yes
  and  [CORE_HOUSE]="No"

THEN:
       Extras are not met
----------------------------------------
RULE NUMBER: 22
IF:
       [COASTAL_REG]="E"
  and  Is the site of your home closer than 15km from the coast
  and  [COASTAL]="No"

THEN:
       Extras are not met
----------------------------------------
RULE NUMBER: 23
IF:
       [COASTAL_REG]="A"
  and  Is the site of your home closer than 15km from the coast
  and  [COASTAL]="No"

THEN:
       Extras are not met
```

```
RULE NUMBER: 24
IF:
        Extras are met

THEN:
        [E] IS GIVEN THE VALUE [E]+1
  and   FRAME("RS", #CLIM#=[COUNT], #EXTRAS#:=[E])
-----------------------------------------
RULE NUMBER: 25
IF:
        [RS_TYPE]="Unit"
  and    How would you best describe yourself? ^^Small scale
contractor^^ OR
        Artisan OR ^^Self-builder^^
  and   [FIN_AVAIL]>[FIN_UNIT_DRAFT]

THEN:
        UNIT or SYSTEM has passed initial draft financial test?
Yes
  and   FRAME("RS", #EXTRAS#=[X], #FIN#:=[F])
-----------------------------------------
RULE NUMBER: 26
IF:
        [RS_TYPE]="Sys"
  and    How would you best describe yourself? ^^Small scale
contractor^^ OR
        Artisan OR ^^Self-builder^^
  and   You can afford approximately [[AREA_AFF]] [[SYS_UNITS]]
of the
        [[SYS_NAME]]. Is this acceptable to you i.e. do you wish
to
        continue investigating this roofing type? Yes

THEN:
        UNIT or SYSTEM has passed initial draft financial test?
Yes
  and   FRAME("RS", #EXTRAS#=[X], #FIN#:=[F])

ELSE:
        UNIT or SYSTEM has passed initial draft financial test?
No
-----------------------------------------
RULE NUMBER: 27
IF:
        UNIT or SYSTEM has passed initial draft financial test?
Yes

THEN:
        [F] IS GIVEN THE VALUE ([F]+1)
-----------------------------------------
RULE NUMBER: 28
IF:
        [RS_TYPE_FIN]="Unit"

THEN:
        Roofing type for modules check is a unit
-----------------------------------------
RULE NUMBER: 29
IF:
        [RS_TYPE_FIN]="Sys"

THEN:
        Roofing type for modules check is a system
```

```
RULE NUMBER: 30
IF:
        Roofing type for modules check is a unit
  and   [MOD_UNITS]>0

THEN:
        Module is required
-----------------------------------
RULE NUMBER: 31
IF:
        Roofing type for modules check is a system
  and   [MOD_SYS]>0

THEN:
        Module is required

ELSE:
        Module is not required
-----------------------------------
RULE NUMBER: 32
IF:
        [MOD_AVAIL]>0

THEN:
        Module is available
-----------------------------------
RULE NUMBER: 33
IF:
        [MOD_AVAIL_NEW]>0

THEN:
        Module is available
-----------------------------------
RULE NUMBER: 34
IF:
        [MOD_UNAVAIL_NEW]>0

THEN:
        Module is not available
-----------------------------------
RULE NUMBER: 35
IF:
        Roofing type for modules check is a unit
  and   [MOD_AVAIL]=0
  and   [MOD_AVAIL_NEW]=0
  and   [MOD_UNAVAIL_NEW]=0
  and   Is the [[MOD_NAME]] range of modules available to you?
(i.e. owned or
        purchaseable) Yes

THEN:
        Module is available
  and   FRAME("SUPPLIER", #NO#=[COUNTER], #MOD_NEW.Y#:=1)
-----------------------------------
RULE NUMBER: 36
IF:
        Roofing type for modules check is a system
  and   [MOD_AVAIL]=0
  and   [MOD_AVAIL_NEW]=0
  and   [MOD_UNAVAIL_NEW]=0
  and   Are [[MOD_NAME]] available to you? Yes

THEN:
        Module is available
  and   FRAME("SUPPLIER", #NO#=[COUNTER], #MOD_NEW.Y#:=1)
  and   FRAME("SY_MOD", #RS#=[RS_NO_FIN], $WANT$:="B")
```

```
RULE NUMBER: 37
IF:
        Roofing type for modules check is a unit
  and   [MOD_AVAIL]=0
  and   [MOD_AVAIL_NEW]=0
  and   [MOD_UNAVAIL_NEW]=0
  and   Is the [[MOD_NAME]] range of modules available to you?
(i.e. owned or
        purchaseable) No

THEN:
        Module is not available
  and   FRAME("SUPPLIER", #NO#=[COUNTER], #MOD_NEW.N#:=1)
----------------------------------------
RULE NUMBER: 38
IF:
        Roofing type for modules check is a system
  and   [MOD_AVAIL]=0
  and   [MOD_AVAIL_NEW]=0
  and   [MOD_UNAVAIL_NEW]=0
  and   Are [[MOD_NAME]] available to you? No
  and   [[MOD_NAME]] are not available in the community. Are you
interested in
        investigating the possibility of building your own? Yes

THEN:
        Module is available
  and   FRAME("SUPPLIER", #NO#=[COUNTER], #MOD_NEW.Y#:=1)
  and   FRAME("SY_MOD", #RS#=[RS_NO_FIN], $WANT$:="S")

ELSE:
        Module is not available
  and   FRAME("SUPPLIER", #NO#=[COUNTER], #MOD_NEW.N#:=1)
  and   FRAME("SY_MOD", #RS#=[RS_NO_FIN], $WANT$:="")
----------------------------------------
RULE NUMBER: 39
IF:
        Module is required
  and   Module is available

THEN:
        Module is OK
  and   [COUNTER] IS GIVEN THE VALUE [CURRENT_RS_NUM]
----------------------------------------
RULE NUMBER: 40
IF:
        Module is required
  and   Module is not available

THEN:
        Module is not OK
  and   [COUNTER] IS GIVEN THE VALUE [CURRENT_RS_NUM]
----------------------------------------
RULE NUMBER: 41
IF:
        Module is not required

THEN:
        Module is OK
----------------------------------------
RULE NUMBER: 42
IF:
        Module is OK

THEN:
        [D] IS GIVEN THE VALUE ([D]+1)
```

```
  and  FRAME("RS", #FIN#=[X], #MODS#:=[D])
-------------------------------------------
RULE NUMBER: 43
IF:
       [RS_TYPE_MOD]="Unit"

THEN:
       Roofing type for equipment check is a unit
-------------------------------------------
RULE NUMBER: 44
IF:
       [RS_TYPE_MOD]="Sys"

THEN:
       Roofing type for equipment check is a system
-------------------------------------------
RULE NUMBER: 45
IF:
       Roofing type for equipment check is a unit
  and  [EQUIP_UNITS]>0

THEN:
       Equipment is  required
-------------------------------------------
RULE NUMBER: 46
IF:
       Roofing type for equipment check is a system
  and  [EQUIP_SYS]>0

THEN:
       Equipment is  required

ELSE:
       Equipment is not required
-------------------------------------------
RULE NUMBER: 47
IF:
       [EQUIP_AVAIL]>0

THEN:
       Equipment is available
-------------------------------------------
RULE NUMBER: 48
IF:
       [EQUIP_AVAIL_NEW]>0

THEN:
       Equipment is available
-------------------------------------------
RULE NUMBER: 49
IF:
       [EQUIP_UNAVAIL_NEW]>0

THEN:
       Equipment is not available
-------------------------------------------
RULE NUMBER: 50
IF:
       [EQUIP_AVAIL]=0
  and  [EQUIP_AVAIL_NEW]=0
  and  [EQUIP_UNAVAIL_NEW]=0
  and  Is/are  a/any  [[EQUIP_NAME]]/s  available to you? Yes

THEN:
       Equipment is available
  and  FRAME("SUPPLIER", #NO#=[COUNTER], #EQU_NEW.Y#:=1)
```

```
RULE NUMBER: 51
IF:
        [EQUIP_AVAIL]=0
  and   [EQUIP_AVAIL_NEW]=0
  and   [EQUIP_UNAVAIL_NEW]=0
  and   Is/are  a/any  [[EQUIP_NAME]]/s  available to you? No

THEN:
        Equipment is not available
  and   FRAME("SUPPLIER", #NO#=[COUNTER], #EQU_NEW.N#:=1)
-----------------------------------------
RULE NUMBER: 52
IF:
        Equipment is  required
  and   Equipment is available

THEN:
        Equipment is OK
-----------------------------------------
RULE NUMBER: 53
IF:
        Equipment is  required
  and   Equipment is not available

THEN:
        Equipment is not OK
  and   [COUNTER] IS GIVEN THE VALUE [EQUIP_NUM]
-----------------------------------------
RULE NUMBER: 54
IF:
        Equipment is not required

THEN:
        Equipment is OK
-----------------------------------------
RULE NUMBER: 55
IF:
        Equipment is OK

THEN:
        [Q] IS GIVEN THE VALUE ([Q]+1)
  and   FRAME("RS", #MODS#=[X], #EQUIP#:=[Q])
-----------------------------------------
RULE NUMBER: 56
IF:
        [RS_TYPE_EQUIP]="Unit"

THEN:
        Roofing type for materials check is a unit
-----------------------------------------
RULE NUMBER: 57
IF:
        [RS_TYPE_EQUIP]="Sys"

THEN:
        Roofing type for materials check is a system
-----------------------------------------
RULE NUMBER: 58
IF:
        Roofing type for materials check is a unit
  and   [MAT_UNITS]>0

THEN:
        Material is required
-----------------------------------------
```

```
RULE NUMBER: 59
IF:
        Roofing type for materials check is a system
  and   [MAT_SYS]>0

THEN:
        Material is required

ELSE:
        Material is not required
-----------------------------------------
RULE NUMBER: 60
IF:
        [MAT_AVAIL]>0

THEN:
        Material is available
-----------------------------------------
RULE NUMBER: 61
IF:
        [MAT_AVAIL_NEW]>0

THEN:
        Material is available
-----------------------------------------
RULE NUMBER: 62
IF:
        [MAT_UNAVAIL_NEW]>0

THEN:
        Material is not available
-----------------------------------------
RULE NUMBER: 63
IF:
        [MAT_AVAIL]=0
  and   [MAT_AVAIL_NEW]=0
  and   [MAT_UNAVAIL_NEW]=0
  and   Is/are  a/any  [[MAT_NAME]]/s available to you? (owned,
obtainable or
        purchaseable) Yes

THEN:
        Material is available
  and   FRAME("SUPPLIER", #NO#=[COUNTER], #MAT_NEW.Y#:=1)
-----------------------------------------
RULE NUMBER: 64
IF:
        [MAT_AVAIL]=0
  and   [MAT_AVAIL_NEW]=0
  and   [MAT_UNAVAIL_NEW]=0
  and   Is/are  a/any  [[MAT_NAME]]/s available to you? (owned,
obtainable or
        purchaseable) No

THEN:
        Material is not available
  and   FRAME("SUPPLIER", #NO#=[COUNTER], #MAT_NEW.N#:=1)
-----------------------------------------
RULE NUMBER: 65
IF:
        Material is required
  and   Material is available

THEN:
        Material is OK
```

```
RULE NUMBER: 66
IF:
       Material is required
  and  Material is not available

THEN:
       Material is not OK
  and  [COUNTER] IS GIVEN THE VALUE [MAT_NUM]
----------------------------------------
RULE NUMBER: 67
IF:
       Material is not required

THEN:
       Material is OK
----------------------------------------
RULE NUMBER: 68
IF:
       Material is OK

THEN:
       [M] IS GIVEN THE VALUE ([M]+1)
  and  FRAME("RS", #EQUIP#=[X], #MATS#:=[M])
----------------------------------------
RULE NUMBER: 69
IF:
       [RS_TYPE_MAT]="Unit"

THEN:
       Roofing Type for tools check is a unit
----------------------------------------
RULE NUMBER: 70
IF:
       [RS_TYPE_MAT]="Sys"

THEN:
       Roofing Type for tools check is a system
----------------------------------------
RULE NUMBER: 71
IF:
       Roofing Type for tools check is a unit
  and  [TOOL_UNITS]>0

THEN:
       Tool is required
----------------------------------------
RULE NUMBER: 72
IF:
       Roofing Type for tools check is a system
  and  [TOOL_SYS]>0

THEN:
       Tool is required

ELSE:
       Tool is not required
----------------------------------------
RULE NUMBER: 73
IF:
       [TL_AVAIL]>0

THEN:
       Tool is available
```

```
RULE NUMBER: 74
IF:
        [TL_AVAIL_NEW]>0

THEN:
        Tool is available
----------------------------------------
RULE NUMBER: 75
IF:
        [TL_UNAVAIL_NEW]>0

THEN:
        Tool is not available
----------------------------------------
RULE NUMBER: 76
IF:
        [TL_AVAIL]=0
  and   [TL_AVAIL_NEW]=0
  and   Is/are  a/any  [[TOOL_NAME]]/s available to you? (i.e.
owned,
        borrowable, rentable or purchaseable) Yes

THEN:
        Tool is available
  and   FRAME("SUPPLIER", #NO#=[COUNTER], #TL_NEW.Y#:=1)
----------------------------------------
RULE NUMBER: 77
IF:
        [TL_AVAIL]=0
  and   [TL_AVAIL_NEW]=0
  and   Is/are  a/any  [[TOOL_NAME]]/s available to you? (i.e.
owned,
        borrowable, rentable or purchaseable) No

THEN:
        Tool is not available
  and   FRAME("SUPPLIER", #NO#=[COUNTER], #TL_NEW.N#:=1)
----------------------------------------
RULE NUMBER: 78
IF:
        Tool is required
  and   Tool is available

THEN:
        Tool is OK
----------------------------------------
RULE NUMBER: 79
IF:
        Tool is required
  and   Tool is not available

THEN:
        Tool is not OK
  and   [COUNTER] IS GIVEN THE VALUE [TOOL_NUM]
----------------------------------------
RULE NUMBER: 80
IF:
        Tool is not required

THEN:
        Tool is OK
```

```
RULE NUMBER: 81
IF:
        Tool is OK

THEN:
        [T] IS GIVEN THE VALUE ([T]+1)
  and   FRAME("RS", #MATS#:=[X], #TOOLS#:=[T])
-----------------------------------------
RULE NUMBER: 82
IF:
        [RS_TYPE_TOOLS]="Unit"

THEN:
        Roofing type for Labour check is a unit
-----------------------------------------
RULE NUMBER: 83
IF:
        [RS_TYPE_TOOLS]="Sys"

THEN:
        Roofing type for Labour check is a system
-----------------------------------------
RULE NUMBER: 84
IF:
        Roofing type for Labour check is a unit
  and   [LAB_UNITS]>0

THEN:
        Labour is  required
-----------------------------------------
RULE NUMBER: 85
IF:
        Roofing type for Labour check is a system
  and   [LAB_SYS]>0

THEN:
        Labour is  required

ELSE:
        Labour is not required
-----------------------------------------
RULE NUMBER: 86
IF:
        [LAB_AVAIL]>0

THEN:
        Labour is available
-----------------------------------------
RULE NUMBER: 87
IF:
        [LAB_AVAIL_NEW]>0

THEN:
        Labour is available
-----------------------------------------
RULE NUMBER: 88
IF:
        [LAB_UNAVAIL_NEW]>0

THEN:
        Labour is not available
-----------------------------------------
RULE NUMBER: 89
IF:
        [LAB_AVAIL]=0
  and   [LAB_AVAIL_NEW]=0
```

```
  and   [LAB_UNAVAIL_NEW]=0
  and   Are any [[LAB_NAME]] labourers available? Yes

THEN:
        Labour is available
  and   FRAME("SUPPLIER", #NO#=[COUNTER], #LAB_NEW.Y#:=1)
----------------------------------------
RULE NUMBER: 90
IF:
        [LAB_AVAIL]=0
  and   [LAB_AVAIL_NEW]=0
  and   [LAB_UNAVAIL_NEW]=0
  and   Are any [[LAB_NAME]] labourers available? No

THEN:
        Labour is not available
  and   FRAME("SUPPLIER", #NO#=[COUNTER], #LAB_NEW.N#:=1)
----------------------------------------
RULE NUMBER: 91
IF:
        Labour is  required
  and   Labour is available

THEN:
        Labour is OK
----------------------------------------
RULE NUMBER: 92
IF:
        Labour is  required
  and   Labour is not available

THEN:
        Labour is not OK
  and   [COUNTER] IS GIVEN THE VAL'E [LAB_NUM]
----------------------------------------
RULE NUMBER: 93
IF:
        Labour is not required

THEN:
        Labour is OK
----------------------------------------
RULE NUMBER: 94
IF:
        Labour is OK

THEN:
        [L] IS GIVEN THE VALUE ([L]+1)
  and   FRAME("RS", #TOOLS#=[X], #LABOUR#:=[L])
----------------------------------------
RULE NUMBER: 95
IF:
        [L]<1

THEN:
        [RS1] IS GIVEN THE VALUE ""
  and   [RS2] IS GIVEN THE VALUE ""
  and   [RS3] IS GIVEN THE VALUE ""
  and   [RS4] IS GIVEN THE VALUE ""
  and   [RS5] IS GIVEN THE VALUE ""
  and   [RS6] IS GIVEN THE VALUE ""
  and   [RS7] IS GIVEN THE VALUE ""
  and   [RS8] IS GIVEN THE VALUE ""
  and   [RS9] IS GIVEN THE VALUE ""
  and   [RS10] IS GIVEN THE VALUE ""
```

```
RULE NUMBER: 96
IF:
        [L]<2

THEN:
        [RS2] IS GIVEN THE VALUE ""
  and   [RS3] IS GIVEN THE VALUE ""
  and   [RS4] IS GIVEN THE VALUE ""
  and   [RS5] IS GIVEN THE VALUE ""
  and   [RS6] IS GIVEN THE VALUE ""
  and   [RS7] IS GIVEN THE VALUE ""
  and   [RS8] IS GIVEN THE VALUE ""
  and   [RS9] IS GIVEN THE VALUE ""
  and   [RS10] IS GIVEN THE VALUE ""
-----------------------------------------
RULE NUMBER: 97
IF:
        [L]<3

THEN:
        [RS3] IS GIVEN THE VALUE ""
  and   [RS4] IS GIVEN THE VALUE ""
  and   [RS5] IS GIVEN THE VALUE ""
  and   [RS6] IS GIVEN THE VALUE ""
  and   [RS7] IS GIVEN THE VALUE ""
  and   [RS8] IS GIVEN THE VALUE ""
  and   [RS9] IS GIVEN THE VALUE ""
  and   [RS10] IS GIVEN THE VALUE ""
-----------------------------------------
RULE NUMBER: 98
IF:
        [L]<4

THEN:
        [RS4] IS GIVEN THE VALUE ""
  and   [RS5] IS GIVEN THE VALUE ""
  and   [RS6] IS GIVEN THE VALUE ""
  and   [RS7] IS GIVEN THE VALUE ""
  and   [RS8] IS GIVEN THE VALUE ""
  and   [RS9] IS GIVEN THE VALUE ""
  and   [RS10] IS GIVEN THE VALUE ""
-----------------------------------------
RULE NUMBER: 99
IF:
        [L]<5

THEN:
        [RS5] IS GIVEN THE VALUE ""
  and   [RS6] IS GIVEN THE VALUE ""
  and   [RS7] IS GIVEN THE VALUE ""
  and   [RS8] IS GIVEN THE VALUE ""
  and   [RS9] IS GIVEN THE VALUE ""
  and   [RS10] IS GIVEN THE VALUE ""
-----------------------------------------
RULE NUMBER: 100
IF:
        [L]<6

THEN:
        [RS6] IS GIVEN THE VALUE ""
  and   [RS7] IS GIVEN THE VALUE ""
  and   [RS8] IS GIVEN THE VALUE ""
  and   [RS9] IS GIVEN THE VALUE ""
  and   [RS10] IS GIVEN THE VALUE ""
```

```
RULE NUMBER: 101
IF:
        [L]<7

THEN:
        [RS7] IS GIVEN THE VALUE ""
  and   [RS8] IS GIVEN THE VALUE ""
  and   [RS9] IS GIVEN THE VALUE ""
  and   [RS10] IS GIVEN THE VALUE ""
-----------------------------------------
RULE NUMBER: 102
IF:
        [L]<8

THEN:
        [RS8] IS GIVEN THE VALUE ""
  and   [RS9] IS GIVEN THE VALUE ""
  and   [RS10] IS GIVEN THE VALUE ""
-----------------------------------------
RULE NUMBER: 103
IF:
        [L]<9

THEN:
        [RS9] IS GIVEN THE VALUE ""
  and   [RS10] IS GIVEN THE VALUE ""
-----------------------------------------
RULE NUMBER: 104
IF:
        [L]<10

THEN:
        [RS10] IS GIVEN THE VALUE ""
-----------------------------------------
RULE NUMBER: 105
IF:
        [COUNT]=1
  and  You have passed the climatic, extras, materials, modules,
tools,
        equipment and labour and financial constraints of the
following
        roofing types. Select those that you would like to further

        investigate: [[RS1]]

THEN:
        [A] IS GIVEN THE VALUE [A]+1
  and   FRAME("RS", #LABOUR#=1, #ACCEPT#:=[A])
-----------------------------------------
RULE NUMBER: 106
IF:
        [COUNT]=2
  and  You have passed the climatic, extras, materials, modules,
tools,
        equipment and labour and financial constraints of the
following
        roofing types. Select those that you would like to further

        investigate: [[RS2]]

THEN:
        [A] IS GIVEN THE VALUE [A]+1
  and   FRAME("RS", #LABOUR#=2, #ACCEPT#:=[A])
```

```
RULE NUMBER: 107
IF:
        [COUNT]=3
  and  You have passed the climatic, extras, materials, modules,
tools,
        equipment and labour and financial constraints of the
following
        roofing types. Select those that you would like to further

        investigate: [[RS3]]

THEN:
        [A] IS GIVEN THE VALUE [A]+1
  and  FRAME("RS", #LABOUR#=3, #ACCEPT#:=[A])
----------------------------------------
RULE NUMBER: 108
IF:
        [COUNT]=4
  and  You have passed the climatic, extras, materials, modules,
tools,
        equipment and labour and financial constraints of the
following
        roofing types. Select those that you would like to further

        investigate: [[RS4]]

THEN:
        [A] IS GIVEN THE VALUE [A]+1
  and  FRAME("RS", #LABOUR#=4, #ACCEPT#:=[A])
----------------------------------------
RULE NUMBER: 109
IF:
        [COUNT]=5
  and  You have passed the climatic, extras, materials, modules,
tools,
        equipment and labour and financial constraints of the
following
        roofing types. Select those that you would like to further

        investigate: [[RS5]]

THEN:
        [A] IS GIVEN THE VALUE [A]+1
  and  FRAME("RS", #LABOUR#=5, #ACCEPT#:=[A])
----------------------------------------
RULE NUMBER: 110
IF:
        [COUNT]=6
  and  You have passed the climatic, extras, materials, modules,
tools,
        equipment and labour and financial constraints of the
following
        roofing types. Select those that you would like to further

        investigate: [[RS6]]

THEN:
        [A] IS GIVEN THE VALUE [A]+1
  and  FRAME("RS", #LABOUR#=6, #ACCEPT#:=[A])
----------------------------------------
RULE NUMBER: 111
IF:
        [COUNT]=7
  and  You have passed the climatic, extras, materials, modules,
tools,
        equipment and labour and financial constraints of the
```

```
following
        roofing types. Select those that you would like to further

        investigate: [[RS7]]

THEN:
        [A] IS GIVEN THE VALUE [A]+1
  and   FRAME("RS", #LABOUR#=7, #ACCEPT#:=[A])
----------------------------------------
RULE NUMBER: 112
IF:
        [COUNT]=8
  and   You have passed the climatic, extras, materials, modules,
tools,
        equipment and labour and financial constraints of the
following
        roofing types. Select those that you would like to further

        investigate: [[RS8]]

THEN:
        [A] IS GIVEN THE VALUE [A]+1
  and   FRAME("RS", #LABOUR#=8, #ACCEPT#:=[A])
----------------------------------------
RULE NUMBER: 113
IF:
        [COUNT]=9
  and   You have passed the climatic, extras, materials, modules,
tools,
        equipment and labour and financial constraints of the
following
        roofing types. Select those that you would like to further

        investigate: [[RS9]]

THEN:
        [A] IS GIVEN THE VALUE [A]+1
  and   FRAME("RS", #LABOUR#=9, #ACCEPT#:=[A])
----------------------------------------
RULE NUMBER: 114
IF:
        [COUNT]=10
  and   You have passed the climatic, extras, materials, modules,
tools,
        equipment and labour and financial constraints of the
following
        roofing types. Select those that you would like to further

        investigate: [[RS10]]

THEN:
        [A] IS GIVEN THE VALUE [A]+1
  and   FRAME("RS", #LABOUR#=10, #ACCEPT#:=[A])
----------------------------------------
RULE NUMBER: 115
IF:
        [RS_TYPE2]='Unit"

THEN:
        [TYPE] IS GIVEN THE VALUE 1

ELSE:
        [TYPE] IS GIVEN THE VALUE 0
```

```
RULE NUMBER: 116
IF:
        [COUNTER]<=[NO_SUBUNITS]
  and   How would you best describe yourself? ^^Small scale
contractor^^
  and   [FIN_AVAIL]>=[CONT]

THEN:
        Sub unit has passed costing test
-----------------------------------------
RULE NUMBER: 117
IF:
        [COUNTER]<=[NO_SUBUNITS]
  and   How would you best describe yourself? ^^Small scale
contractor^^
  and   [FIN_AVAIL]<[CONT]

THEN:
        Sub unit has failed costing test
-----------------------------------------
RULE NUMBER: 118
IF:
        [COUNTER]<=[NO_SUBUNITS]
  and   How would you best describe yourself? Artisan
  and   [FIN_AVAIL]>=[ART]

THEN:
        Sub unit has passed costing test
-----------------------------------------
RULE NUMBER: 119
IF:
        [COUNTER]<=[NO_SUBUNITS]
  and   How would you best describe yourself? Artisan
  and   [FIN_AVAIL]<[ART]

THEN:
        Sub unit has failed costing test
-----------------------------------------
RULE NUMBER: 120
IF:
        [COUNTER]<=[NO_SUBUNITS]
  and   How would you best describe yourself? ^^Self-builder^^
  and   [FIN_AVAIL]>=[SB]

THEN:
        Sub unit has passed costing test
-----------------------------------------
RULE NUMBER: 121
IF:
        [COUNTER]<=[NO_SUBUNITS]
  and   How would you best describe yourself? ^^Self-builder^^
  and   [FIN_AVAIL]<[SB]

THEN:
        Sub unit has failed costing test
-----------------------------------------
RULE NUMBER: 122
IF:
        [COUNTER]<=[NO_SUBUNITS]
  and   Sub unit has failed costing test
  and   [COUNTER]=1

THEN:
        [SU1] IS GIVEN THE VALUE ""
  and   [SU1_AREA] IS GIVEN THE VALUE 0
  and   [SU1_AREA_U] IS GIVEN THE VALUE ""
```

```
RULE NUMBER: 123
IF:
        [COUNTER]<=[NO_SUBUNITS]
  and   Sub unit has failed costing test
  and   [COUNTER]=2

THEN:
        [SU2] IS GIVEN THE VALUE ""
  and   [SU2_AREA] IS GIVEN THE VALUE 0
  and   [SU3_AREA_U] IS GIVEN THE VALUE ""
-----------------------------------------
RULE NUMBER: 124
IF:
        [COUNTER]<=[NO_SUBUNITS]
  and   Sub unit has failed costing test
  and   [COUNTER]=3

THEN:
        [SU3] IS GIVEN THE VALUE ""
  and   [SU3_AREA] IS GIVEN THE VALUE 0
  and   [SU3_AREA_U] IS GIVEN THE VALUE ""
-----------------------------------------
RULE NUMBER: 125
IF:
        [COUNTER]<=[NO_SUBUNITS]
  and   Sub unit has failed costing test
  and   [COUNTER]=4

THEN:
        [SU4] IS GIVEN THE VALUE ""
  and   [SU4_AREA] IS GIVEN THE VALUE 0
  and   [SU4_AREA_U] IS GIVEN THE VALUE ""
-----------------------------------------
RULE NUMBER: 126
IF:
        [COUNTER]<=[NO_SUBUNITS]
  and   Sub unit has failed costing test
  and   [COUNTER]=5

THEN:
        [SU5] IS GIVEN THE VALUE ""
  and   [SU5_AREA] IS GIVEN THE VALUE 0
  and   [SU5_AREA_U] IS GIVEN THE VALUE ""
-----------------------------------------
RULE NUMBER: 127
IF:
        [COUNTER]<=[NO_SUBUNITS]
  and   Sub unit has failed costing test
  and   [COUNTER]=6

THEN:
        [SU6] IS GIVEN THE VALUE ""
  and   [SU6_AREA] IS GIVEN THE VALUE 0
  and   [SU6_AREA_U] IS GIVEN THE VALUE ""
-----------------------------------------
RULE NUMBER: 128
IF:
        [COUNTER]<=[NO_SUBUNITS]
  and   Sub unit has failed costing test
  and   [COUNTER]=7

THEN:
        [SU7] IS GIVEN THE VALUE ""
  and   [SU7_AREA] IS GIVEN THE VALUE 0
  and   [SU7_AREA_U] IS GIVEN THE VALUE ""
```

```
RULE NUMBER: 129
IF:
        [COUNTER]<=[NO_SUBUNITS]
  and   Sub unit has failed costing test
  and   [COUNTER]=8

THEN:
        [SU8] IS GIVEN THE VALUE ""
  and   [SU8_AREA] IS GIVEN THE VALUE 0
  and   [SU8_AREA_U] IS GIVEN THE VALUE ""
-----------------------------------------
RULE NUMBER: 130
IF:
        [COUNTER]<=[NO_SUBUNITS]
  and   Sub unit has failed costing test
  and   [COUNTER]=9

THEN:
        [SU9] IS GIVEN THE VALUE ""
  and   [SU9_AREA] IS GIVEN THE VALUE 0
  and   [SU9_AREA_U] IS GIVEN THE VALUE ""
-----------------------------------------
RULE NUMBER: 131
IF:
        [COUNTER]<=[NO_SUBUNITS]
  and   Sub unit has failed costing test
  and   [COUNTER]=10

THEN:
        [SU10] IS GIVEN THE VALUE ""
  and   [SU10_AREA] IS GIVEN THE VALUE 0
  and   [SU10_AREA_U] IS GIVEN THE VALUE ""
-----------------------------------------
RULE NUMBER: 132
IF:
        [COUNTER]<=[NO_SUBUNITS]
  and   Sub unit has failed costing test
  and   [COUNTER]=11

THEN:
        [SU11] IS GIVEN THE VALUE ""
  and   [SU11_AREA] IS GIVEN THE VALUE 0
  and   [SU11_AREA_U] IS GIVEN THE VALUE ""
-----------------------------------------
RULE NUMBER: 133
IF:
        [COUNTER]<=[NO_SUBUNITS]
  and   Sub unit has failed costing test
  and   [COUNTER]=12

THEN:
        [SU12] IS GIVEN THE VALUE ""
  and   [SU12_AREA] IS GIVEN THE VALUE 0
  and   [SU12_AREA_U] IS GIVEN THE VALUE ""
-----------------------------------------
RULE NUMBER: 134
IF:
        [COUNTER]<=[NO_SUBUNITS]
  and   Sub unit has failed costing test
  and   [COUNTER]=13

THEN:
        [SU13] IS GIVEN THE VALUE ""
  and   [SU13_AREA] IS GIVEN THE VALUE 0
  and   [SU13_AREA_U] IS GIVEN THE VALUE ""
```

```
RULE NUMBER: 135
IF:
        [COUNTER]<=[NO_SUBUNITS]
  and   Sub unit has failed costing test
  and   [COUNTER]=14

THEN:
        [SU14] IS GIVEN THE VALUE ""
  and   [SU14_AREA] IS GIVEN THE VALUE 0
  and   [SU14_AREA_U] IS GIVEN THE VALUE ""
-----------------------------------------
RULE NUMBER: 136
IF:
        [COUNTER]<=[NO_SUBUNITS]
  and   Sub unit has failed costing test
  and   [COUNTER]=15

THEN:
        [SU15] IS GIVEN THE VALUE ""
  and   [SU15_AREA] IS GIVEN THE VALUE 0
  and   [SU15_AREA_U] IS GIVEN THE VALUE ""
-----------------------------------------
RULE NUMBER: 137
IF:
        [COUNTER]>[NO_SUBUNITS]
  and   [COUNTER]=1

THEN:
        [SU1] IS GIVEN THE VALUE ""
  and   [SU1_AREA] IS GIVEN THE VALUE 0
  and   [SU1_AREA_U] IS GIVEN THE VALUE ""
  and   [SU2] IS GIVEN THE VALUE ""
  and   [SU2_AREA] IS GIVEN THE VALUE 0
  and   [SU2_AREA_U] IS GIVEN THE VALUE ""
  and   [SU3] IS GIVEN THE VALUE ""
  and   [SU3_AREA] IS GIVEN THE VALUE 0
  and   [SU3_AREA_U] IS GIVEN THE VALUE ""
  and   [SU4] IS GIVEN THE VALUE ""
  and   [SU4_AREA] IS GIVEN THE VALUE 0
  and   [SU4_AREA_U] IS GIVEN THE VALUE ""
  and   [SU5] IS GIVEN THE VALUE ""
  and   [SU5_AREA] IS GIVEN THE VALUE 0
  and   [SU5_AREA_U] IS GIVEN THE VALUE ""
  and   [SU6] IS GIVEN THE VALUE ""
  and   [SU6_AREA] IS GIVEN THE VALUE 0
  and   [SU6_AREA_U] IS GIVEN THE VALUE ""
  and   [SU7] IS GIVEN THE VALUE ""
  and   [SU7_AREA] IS GIVEN THE VALUE 0
  and   [SU7_AREA_U] IS GIVEN THE VALUE ""
  and   [SU8] IS GIVEN THE VALUE ""
  and   [SU8_AREA] IS GIVEN THE VALUE 0
  and   [SU8_AREA_U] IS GIVEN THE VALUE ""
  and   [SU9] IS GIVEN THE VALUE ""
  and   [SU9_AREA] IS GIVEN THE VALUE 0
  and   [SU9_AREA_U] IS GIVEN THE VALUE ""
  and   [SU10] IS GIVEN THE VALUE ""
  and   [SU10_AREA] IS GIVEN THE VALUE 0
  and   [SU10_AREA_U] IS GIVEN THE VALUE ""
  and   [SU11] IS GIVEN THE VALUE ""
  and   [SU11_AREA] IS GIVEN THE VALUE 0
  and   [SU11_AREA_U] IS GIVEN THE VALUE ""
  and   [SU12] IS GIVEN THE VALUE ""
  and   [SU12_AREA] IS GIVEN THE VALUE 0
  and   [SU12_AREA_U] IS GIVEN THE VALUE ""
  and   [SU13] IS GIVEN THE VALUE ""
  and   [SU13_AREA] IS GIVEN THE VALUE 0
```

```
  and   [SU13_AREA_U] IS GIVEN THE VALUE ""
  and   [SU14] IS GIVEN THE VALUE ""
  and   [SU14_AREA] IS GIVEN THE VALUE 0
  and   [SU14_AREA_U] IS GIVEN THE VALUE ""
  and   [SU15] IS GIVEN THE VALUE ""
  and   [SU15_AREA] IS GIVEN THE VALUE 0
  and   [SU15_AREA_U] IS GIVEN THE VALUE ""
  and   [U] IS GIVEN THE VALUE 250
-----------------------------------------
RULE NUMBER: 138
IF:
        [COUNTER]>[NO_SUBUNITS]
  and   [COUNTER]=2

THEN:
        [SU2] IS GIVEN THE VALUE ""
  and   [SU2_AREA] IS GIVEN THE VALUE 0
  and   [SU2_AREA_U] IS GIVEN THE VALUE ""
  and   [SU3] IS GIVEN THE VALUE ""
  and   [SU3_AREA] IS GIVEN THE VALUE 0
  and   [SU3_AREA_U] IS GIVEN THE VALUE ""
  and   [SU4] IS GIVEN THE VALUE ""
  and   [SU4_AREA] IS GIVEN THE VALUE 0
  and   [SU4_AREA_U] IS GIVEN THE VALUE ""
  and   [SU5] IS GIVEN THE VALUE ""
  and   [SU5_AREA] IS GIVEN THE VALUE 0
  and   [SU5_AREA_U] IS GIVEN THE VALUE ""
  and   [SU6] IS GIVEN THE VALUE ""
  and   [SU6_AREA] IS GIVEN THE VALUE 0
  and   [SU6_AREA_U] IS GIVEN THE VALUE ""
  and   [SU7] IS GIVEN THE VALUE ""
  and   [SU7_AREA] IS GIVEN THE VALUE 0
  and   [SU7_AREA_U] IS GIVEN THE VALUE ""
  and   [SU8] IS GIVEN THE VALUE ""
  and   [SU8_AREA] IS GIVEN THE VALUE 0
  and   [SU8_AREA_U] IS GIVEN THE VALUE ""
  and   [SU9] IS GIVEN THE VALUE ""
  and   [SU9_AREA] IS GIVEN THE VALUE 0
  and   [SU9_AREA_U] IS GIVEN THE VALUE ""
  and   [SU10] IS GIVEN THE VALUE ""
  and   [SU10_AREA] IS GIVEN THE VALUE 0
  and   [SU10_AREA_U] IS GIVEN THE VALUE ""
  and   [SU11] IS GIVEN THE VALUE ""
  and   [SU11_AREA] IS GIVEN THE VALUE 0
  and   [SU11_AREA_U] IS GIVEN THE VALUE ""
  and   [SU12] IS GIVEN THE VALUE ""
  and   [SU12_AREA] IS GIVEN THE VALUE 0
  and   [SU12_AREA_U] IS GIVEN THE VALUE ""
  and   [SU13] IS GIVEN THE VALUE ""
  and   [SU13_AREA] IS GIVEN THE VALUE 0
  and   [SU13_AREA_U] IS GIVEN THE VALUE ""
  and   [SU14] IS GIVEN THE VALUE ""
  and   [SU14_AREA] IS GIVEN THE VALUE 0
  and   [SU14_AREA_U] IS GIVEN THE VALUE ""
  and   [SU15] IS GIVEN THE VALUE ""
  and   [SU15_AREA] IS GIVEN THE VALUE 0
  and   [SU15_AREA_U] IS GIVEN THE VALUE ""
  and   [U] IS GIVEN THE VALUE 250
-----------------------------------------
RULE NUMBER: 139
IF:
        [COUNTER]>[NO_SUBUNITS]
  and   [COUNTER]=3

THEN:
        [SU3] IS GIVEN THE VALUE ""
```

```
   and   [SU3_AREA] IS GIVEN THE VALUE 0
   and   [SU3_AREA_U] IS GIVEN THE VALUE ""
   and   [SU4] IS GIVEN THE VALUE ""
   and   [SU4_AREA] IS GIVEN THE VALUE 0
   and   [SU4_AREA_U] IS GIVEN THE VALUE ""
   and   [SU5] IS GIVEN THE VALUE ""
   and   [SU5_AREA] IS GIVEN THE VALUE 0
   and   [SU5_AREA_U] IS GIVEN THE VALUE ""
   and   [SU6] IS GIVEN THE VALUE ""
   and   [SU6_AREA] IS GIVEN THE VALUE 0
   and   [SU6_AREA_U] IS GIVEN THE VALUE ""
   and   [SU7] IS GIVEN THE VALUE ""
   and   [SU7_AREA] IS GIVEN THE VALUE 0
   and   [SU7_AREA_U] IS GIVEN THE VALUE ""
   and   [SU8] IS GIVEN THE VALUE ""
   and   [SU8_AREA] IS GIVEN THE VALUE 0
   and   [SU8_AREA_U] IS GIVEN THE VALUE ""
   and   [SU9] IS GIVEN THE VALUE ""
   and   [SU9_AREA] IS GIVEN THE VALUE 0
   and   [SU9_AREA_U] IS GIVEN THE VALUE ""
   and   [SU10] IS GIVEN THE VALUE ""
   and   [SU10_AREA] IS GIVEN THE VALUE 0
   and   [SU10_AREA_U] IS GIVEN THE VALUE ""
   and   [SU11] IS GIVEN THE VALUE ""
   and   [SU11_AREA] IS GIVEN THE VALUE 0
   and   [SU11_AREA_U] IS GIVEN THE VALUE ""
   and   [SU12] IS GIVEN THE VALUE ""
   and   [SU12_AREA] IS GIVEN THE VALUE 0
   and   [SU12_AREA_U] IS GIVEN THE VALUE ""
   and   [SU13] IS GIVEN THE VALUE ""
   and   [SU13_AREA] IS GIVEN THE VALUE 0
   and   [SU13_AREA_U] IS GIVEN THE VALUE ""
   and   [SU14] IS GIVEN THE VALUE ""
   and   [SU14_AREA] IS GIVEN THE VALUE 0
   and   [SU14_AREA_U] IS GIVEN THE VALUE ""
   and   [SU15] IS GIVEN THE VALUE ""
   and   [SU15_AREA] IS GIVEN THE VALUE 0
   and   [SU15_AREA_U] IS GIVEN THE VALUE ""
   and   [U] IS GIVEN THE VALUE 250
-----------------------------------------
RULE NUMBER: 140
IF:
         [COUNTER]>[NO_SUBUNITS]
   and   [COUNTER]=4

THEN:
         [SU4] IS GIVEN THE VALUE ""
   and   [SU4_AREA] IS GIVEN THE VALUE 0
   and   [SU4_AREA_U] IS GIVEN THE VALUE ""
   and   [SU5] IS GIVEN THE VALUE ""
   and   [SU5_AREA] IS GIVEN THE VALUE 0
   and   [SU5_AREA_U] IS GIVEN THE VALUE ""
   and   [SU6] IS GIVEN THE VALUE ""
   and   [SU6_AREA] IS GIVEN THE VALUE 0
   and   [SU6_AREA_U] IS GIVEN THE VALUE ""
   and   [SU7] IS GIVEN THE VALUE ""
   and   [SU7_AREA] IS GIVEN THE VALUE 0
   and   [SU7_AREA_U] IS GIVEN THE VALUE ""
   and   [SU8] IS GIVEN THE VALUE ""
   and   [SU8_AREA] IS GIVEN THE VALUE 0
   and   [SU8_AREA_U] IS GIVEN THE VALUE ""
   and   [SU9] IS GIVEN THE VALUE ""
   and   [SU9_AREA] IS GIVEN THE VALUE 0
   and   [SU9_AREA_U] IS GIVEN THE VALUE ""
   and   [SU10] IS GIVEN THE VALUE ""
   and   [SU10_AREA] IS GIVEN THE VALUE 0
```

```
  and   [SU10_AREA_U] IS GIVEN THE VALUE ""
  and   [SU11] IS GIVEN THE VALUE ""
  and   [SU11_AREA] IS GIVEN THE VALUE 0
  and   [SU11_AREA_U] IS GIVEN THE VALUE ""
  and   [SU12] IS GIVEN THE VALUE ""
  and   [SU12_AREA] IS GIVEN THE VALUE 0
  and   [SU12_AREA_U] IS GIVEN THE VALUE ""
  and   [SU13] IS GIVEN THE VALUE ""
  and   [SU13_AREA] IS GIVEN THE VALUE 0
  and   [SU13_AREA_U] IS GIVEN THE VALUE ""
  and   [SU14] IS GIVEN THE VALUE ""
  and   [SU14_AREA] IS GIVEN THE VALUE 0
  and   [SU14_AREA_U] IS GIVEN THE VALUE ""
  and   [SU15] IS GIVEN THE VALUE ""
  and   [SU15_AREA] IS GIVEN THE VALUE 0
  and   [SU15_AREA_U] IS GIVEN THE VALUE ""
  and   [U] IS GIVEN THE VALUE 250
------------------------------------------
RULE NUMBER: 141
IF:
        [COUNTER]>[NO_SUBUNITS]
  and   [COUNTER]=5

THEN:
        [SU5] IS GIVEN THE VALUE ""
  and   [SU5_AREA] IS GIVEN THE VALUE 0
  and   [SU5_AREA_U] IS GIVEN THE VALUE ""
  and   [SU6] IS GIVEN THE VALUE ""
  and   [SU6_AREA] IS GIVEN THE VALUE 0
  and   [SU6_AREA_U] IS GIVEN THE VALUE ""
  and   [SU7] IS GIVEN THE VALUE ""
  and   [SU7_AREA] IS GIVEN THE VALUE 0
  and   [SU7_AREA_U] IS GIVEN THE VALUE ""
  and   [SU8] IS GIVEN THE VALUE ""
  and   [SU8_AREA] IS GIVEN THE VALUE 0
  and   [SU8_AREA_U] IS GIVEN THE VALUE ""
  and   [SU9] IS GIVEN THE VALUE ""
  and   [SU9_AREA] IS GIVEN THE VALUE 0
  and   [SU9_AREA_U] IS GIVEN THE VALUE ""
  and   [SU10] IS GIVEN THE VALUE ""
  and   [SU10_AREA] IS GIVEN THE VALUE 0
  and   [SU10_AREA_U] IS GIVEN THE VALUE ""
  and   [SU11] IS GIVEN THE VALUE ""
  and   [SU11_AREA] IS GIVEN THE VALUE 0
  and   [SU11_AREA_U] IS GIVEN THE VALUE ""
  and   [SU12] IS GIVEN THE VALUE ""
  and   [SU12_AREA] IS GIVEN THE VALUE 0
  and   [SU12_AREA_U] IS GIVEN THE VALUE ""
  and   [SU13] IS GIVEN THE VALUE ""
  and   [SU13_AREA] IS GIVEN THE VALUE 0
  and   [SU13_AREA_U] IS GIVEN THE VALUE ""
  and   [SU14] IS GIVEN THE VALUE ""
  and   [SU14_AREA] IS GIVEN THE VALUE 0
  and   [SU14_AREA_U] IS GIVEN THE VALUE ""
  and   [SU15] IS GIVEN THE VALUE ""
  and   [SU15_AREA] IS GIVEN THE VALUE 0
  and   [SU15_AREA_U] IS GIVEN THE VALUE ""
  and   [U] IS GIVEN THE VALUE 250
------------------------------------------
RULE NUMBER: 142
IF:
        [COUNTER]>[NO_SUBUNITS]
  and   [COUNTER]=6

THEN:
        [SU6] IS GIVEN THE VALUE ""
```

```
   and   [SU6_AREA] IS GIVEN THE VALUE 0
   and   [SU6_AREA_U] IS GIVEN THE VALUE ""
   and   [SU7] IS GIVEN THE VALUE ""
   and   [SU7_AREA] IS GIVEN THE VALUE 0
   and   [SU7_AREA_U] IS GIVEN THE VALUE ""
   and   [SU8] IS GIVEN THE VALUE ""
   and   [SU8_AREA] IS GIVEN THE VALUE 0
   and   [SU8_AREA_U] IS GIVEN THE VALUE ""
   and   [SU9] IS GIVEN THE VALUE ""
   and   [SU9_AREA] IS GIVEN THE VALUE 0
   and   [SU9_AREA_U] IS GIVEN THE VALUE ""
   and   [SU10] IS GIVEN THE VALUE ""
   and   [SU10_AREA] IS GIVEN THE VALUE 0
   and   [SU10_AREA_U] IS GIVEN THE VALUE ""
   and   [SU11] IS GIVEN THE VALUE ""
   and   [SU11_AREA] IS GIVEN THE VALUE 0
   and   [SU11_AREA_U] IS GIVEN THE VALUE ""
   and   [SU12] IS GIVEN THE VALUE ""
   and   [SU12_AREA] IS GIVEN THE VALUE 0
   and   [SU12_AREA_U] IS GIVEN THE VALUE ""
   and   [SU13] IS GIVEN THE VALUE ""
   and   [SU13_AREA] IS GIVEN THE VALUE 0
   and   [SU13_AREA_U] IS GIVEN THE VALUE ""
   and   [SU14] IS GIVEN THE VALUE ""
   and   [SU14_AREA] IS GIVEN THE VALUE 0
   and   [SU14_AREA_U] IS GIVEN THE VALUE ""
   and   [SU15] IS GIVEN THE VALUE ""
   and   [SU15_AREA] IS GIVEN THE VALUE 0
   and   [SU15_AREA_U] IS GIVEN THE VALUE ""
   and   [U] IS GIVEN THE VALUE 250
-----------------------------------------
RULE NUMBER: 143
IF:
         [COUNTER]>[NO_SUBUNITS]
   and   [COUNTER]=7

THEN:
         [SU7] IS GIVEN THE VALUE ""
   and   [SU7_AREA] IS GIVEN THE VALUE 0
   and   [SU7_AREA_U] IS GIVEN THE VALUE ""
   and   [SU8] IS GIVEN THE VALUE ""
   and   [SU8_AREA] IS GIVEN THE VALUE 0
   and   [SU8_AREA_U] IS GIVEN THE VALUE ""
   and   [SU9] IS GIVEN THE VALUE ""
   and   [SU9_AREA] IS GIVEN THE VALUE 0
   and   [SU9_AREA_U] IS GIVEN THE VALUE ""
   and   [SU10] IS GIVEN THE VALUE ""
   and   [SU10_AREA] IS GIVEN THE VALUE 0
   and   [SU10_AREA_U] IS GIVEN THE VALUE ""
   and   [SU11] IS GIVEN THE VALUE ""
   and   [SU11_AREA] IS GIVEN THE VALUE 0
   and   [SU11_AREA_U] IS GIVEN THE VALUE ""
   and   [SU12] IS GIVEN THE VALUE ""
   and   [SU12_AREA] IS GIVEN THE VALUE 0
   and   [SU12_AREA_U] IS GIVEN THE VALUE ""
   and   [SU13] IS GIVEN THE VALUE ""
   and   [SU13_AREA] IS GIVEN THE VALUE 0
   and   [SU13_AREA_U] IS GIVEN THE VALUE ""
   and   [SU14] IS GIVEN THE VALUE ""
   and   [SU14_AREA] IS GIVEN THE VALUE 0
   and   [SU14_AREA_U] IS GIVEN THE VALUE ""
   and   [SU15] IS GIVEN THE VALUE ""
   and   [SU15_AREA] IS GIVEN THE VALUE 0
   and   [SU15_AREA_U] IS GIVEN THE VALUE ""
   and   [U] IS GIVEN THE VALUE 250
```

```
RULE NUMBER: 144
IF:
        [COUNTER]>[NO_SUBUNITS]
  and   [COUNTER]=8

THEN:
        [SU8] IS GIVEN THE VALUE ""
  and   [SU8_AREA] IS GIVEN THE VALUE 0
  and   [SU8_AREA_U] IS GIVEN THE VALUE ""
  and   [SU9] IS GIVEN THE VALUE ""
  and   [SU9_AREA] IS GIVEN THE VALUE 0
  and   [SU9_AREA_U] IS GIVEN THE VALUE ""
  and   [SU10] IS GIVEN THE VALUE ""
  and   [SU10_AREA] IS GIVEN THE VALUE 0
  and   [SU10_AREA_U] IS GIVEN THE VALUE ""
  and   [SU11] IS GIVEN THE VALUE ""
  and   [SU11_AREA] IS GIVEN THE VALUE 0
  and   [SU11_AREA_U] IS GIVEN THE VALUE ""
  and   [SU12] IS GIVEN THE VALUE ""
  and   [SU12_AREA] IS GIVEN THE VALUE 0
  and   [SU12_AREA_U] IS GIVEN THE VALUE ""
  and   [SU13] IS GIVEN THE VALUE ""
  and   [SU13_AREA] IS GIVEN THE VALUE 0
  and   [SU13_AREA_U] IS GIVEN THE VALUE ""
  and   [SU14] IS GIVEN THE VALUE ""
  and   [SU14_AREA] IS GIVEN THE VALUE 0
  and   [SU14_AREA_U] IS GIVEN THE VALUE ""
  and   [SU15] IS GIVEN THE VALUE ""
  and   [SU15_AREA] IS GIVEN THE VALUE 0
  and   [SU15_AREA_U] IS GIVEN THE VALUE ""
  and   [U] IS GIVEN THE VALUE 250
-------------------------------------------
RULE NUMBER: 145
IF:
        [COUNTER]>[NO_SUBUNITS]
  and   [COUNTER]=9

THEN:
        [SU9] IS GIVEN THE VALUE ""
  and   [SU9_AREA] IS GIVEN THE VALUE 0
  and   [SU9_AREA_U] IS GIVEN THE VALUE ""
  and   [SU10] IS GIVEN THE VALUE ""
  and   [SU10_AREA] IS GIVEN THE VALUE 0
  and   [SU10_AREA_U] IS GIVEN THE VALUE ""
  and   [SU11] IS GIVEN THE VALUE ""
  and   [SU11_AREA] IS GIVEN THE VALUE 0
  and   [SU11_AREA_U] IS GIVEN THE VALUE ""
  and   [SU12] IS GIVEN THE VALUE ""
  and   [SU12_AREA] IS GIVEN THE VALUE 0
  and   [SU12_AREA_U] IS GIVEN THE VALUE ""
  and   [SU13] IS GIVEN THE VALUE ""
  and   [SU13_AREA] IS GIVEN THE VALUE 0
  and   [SU13_AREA_U] IS GIVEN THE VALUE ""
  and   [SU14] IS GIVEN THE VALUE ""
  and   [SU14_AREA] IS GIVEN THE VALUE 0
  and   [SU14_AREA_U] IS GIVEN THE VALUE ""
  and   [SU15] IS GIVEN THE VALUE ""
  and   [SU15_AREA] IS GIVEN THE VALUE 0
  and   [SU15_AREA_U] IS GIVEN THE VALUE ""
  and   [U] IS GIVEN THE VALUE 250
-------------------------------------------
RULE NUMBER: 146
IF:
        [COUNTER]>[NO_SUBUNITS]
  and   [COUNTER]=10
```

```
THEN:
        [SU10] IS GIVEN THE VALUE ""
  and   [SU10_AREA] IS GIVEN THE VALUE 0
  and   [SU10_AREA_U] IS GIVEN THE VALUE ""
  and   [SU11] IS GIVEN THE VALUE ""
  and   [SU11_AREA] IS GIVEN THE VALUE 0
  and   [SU11_AREA_U] IS GIVEN THE VALUE ""
  and   [SU12] IS GIVEN THE VALUE ""
  and   [SU12_AREA] IS GIVEN THE VALUE 0
  and   [SU12_AREA_U] IS GIVEN THE VALUE ""
  and   [SU13] IS GIVEN THE VALUE ""
  and   [SU13_AREA] IS GIVEN THE VALUE 0
  and   [SU13_AREA_U] IS GIVEN THE VALUE ""
  and   [SU14] IS GIVEN THE VALUE ""
  and   [SU14_AREA] IS GIVEN THE VALUE 0
  and   [SU14_AREA_U] IS GIVEN THE VALUE ""
  and   [SU15] IS GIVEN THE VALUE ""
  and   [SU15_AREA] IS GIVEN THE VALUE 0
  and   [SU15_AREA_U] IS GIVEN THE VALUE ""
  and   [U] IS GIVEN THE VALUE 250
----------------------------------------
RULE NUMBER: 147
IF:
        [COUNTER]>[NO_SUBUNITS]
  and   [COUNTER]=11

THEN:
        [SU11] IS GIVEN THE VALUE ""
  and   [SU11_AREA] IS GIVEN THE VALUE 0
  and   [SU11_AREA_U] IS GIVEN THE VALUE ""
  and   [SU12] IS GIVEN THE VALUE ""
  and   [SU12_AREA] IS GIVEN THE VALUE 0
  and   [SU12_AREA_U] IS GIVEN THE VALUE ""
  and   [SU13] IS GIVEN THE VALUE ""
  and   [SU13_AREA] IS GIVEN THE VALUE 0
  and   [SU13_AREA_U] IS GIVEN THE VALUE ""
  and   [SU14] IS GIVEN THE VALUE ""
  and   [SU14_AREA] IS GIVEN THE VALUE 0
  and   [SU14_AREA_U] IS GIVEN THE VALUE ""
  and   [SU15] IS GIVEN THE VALUE ""
  and   [SU15_AREA] IS GIVEN THE VALUE 0
  and   [SU15_AREA_U] IS GIVEN THE VALUE ""
  and   [U] IS GIVEN THE VALUE 250
----------------------------------------
RULE NUMBER: 148
IF:
        [COUNTER]>[NO_SUBUNITS]
  and   [COUNTER]=12

THEN:
        [SU12] IS GIVEN THE VALUE ""
  and   [SU12_AREA] IS GIVEN THE VALUE 0
  and   [SU12_AREA_U] IS GIVEN THE VALUE ""
  and   [SU13] IS GIVEN THE VALUE ""
  and   [SU13_AREA] IS GIVEN THE VALUE 0
  and   [SU13_AREA_U] IS GIVEN THE VALUE ""
  and   [SU14] IS GIVEN THE VALUE ""
  and   [SU14_AREA] IS GIVEN THE VALUE 0
  and   [SU14_AREA_U] IS GIVEN THE VALUE ""
  and   [SU15] IS GIVEN THE VALUE ""
  and   [SU15_AREA] IS GIVEN THE VALUE 0
  and   [SU15_AREA_U] IS GIVEN THE VALUE ""
  and   [U] IS GIVEN THE VALUE 250
----------------------------------------
```

```
RULE NUMBER: 149
IF:
        [COUNTER]>[NO_SUBUNITS]
  and   [COUNTER]=13

THEN:
        [SU13] IS GIVEN THE VALUE ""
  and   [SU13_AREA] IS GIVEN THE VALUE 0
  and   [SU13_AREA_U] IS GIVEN THE VALUE ""
  and   [SU14] IS GIVEN THE VALUE ""
  and   [SU14_AREA] IS GIVEN THE VALUE 0
  and   [SU14_AREA_U] IS GIVEN THE VALUE ""
  and   [SU15] IS GIVEN THE VALUE ""
  and   [SU15_AREA] IS GIVEN THE VALUE 0
  and   [SU15_AREA_U] IS GIVEN THE VALUE ""
  and   [U] IS GIVEN THE VALUE 250
----------------------------------------
RULE NUMBER: 150
IF:
        [COUNTER]>[NO_SUBUNITS]
  and   [COUNTER]=14

THEN:
        [SU14] IS GIVEN THE VALUE ""
  and   [SU14_AREA] IS GIVEN THE VALUE 0
  and   [SU14_AREA_U] IS GIVEN THE VALUE ""
  and   [SU15] IS GIVEN THE VALUE ""
  and   [SU15_AREA] IS GIVEN THE VALUE 0
  and   [SU15_AREA_U] IS GIVEN THE VALUE ""
  and   [U] IS GIVEN THE VALUE 250
----------------------------------------
RULE NUMBER: 151
IF:
        [COUNTER]>[NO_SUBUNITS]
  and   [COUNTER]=15

THEN:
        [SU15] IS GIVEN THE VALUE ""
  and   [SU15_AREA] IS GIVEN THE VALUE 0
  and   [SU15_AREA_U] IS GIVEN THE VALUE ""
  and   [U] IS GIVEN THE VALUE 250
----------------------------------------
RULE NUMBER: 152
IF:
        You have selected to investigate the [[UNIT_NOME]] range
further. Which
        of the following sub-units do you wish to investigate?
[[SU1]]
                [[SU1_AREA]][[SU1_AREA_U]]
  and   [SU1]<>""

THEN:
        FRAME("UN_COSTS", #NO#=[FIRST SU], #INVEST#:=1)
----------------------------------------
RULE NUMBER: 153
IF:
        You have selected to investigate the [[UNIT_NOME]] range
further. Which
        of the following sub-units do you wish to investigate?
[[SU2]]
                [[SU2_AREA]][[SU2_AREA_U]]
  and   [SU2]<>""

THEN:
        FRAME("UN_COSTS", #NO#=([FIRST SU]+1), #INVEST#:=1)
```

```
RULE NUMBER: 154
IF:
        You have selected to investigate the [[UNIT_NOME]] range
further. Which
        of the following sub-units do you wish to investigate?
[[SU3]]
                [[SU3_AREA]][[SU3_AREA_U]]
  and   [SU3]<>""

THEN:
        FRAME("UN_COSTS", #NO#=([FIRST SU]+2), #INVEST#:=1)
-----------------------------------------
RULE NUMBER: 155
IF:
        You have selected to investigate the [[UNIT_NOME]] range
further. Which
        of the following sub-units do you wish to investigate?
[[SU4]]
                [[SU4_AREA]][[SU4_AREA_U]]
  and   [SU4]<>""

THEN:
        FRAME("UN_COSTS", #NO#=([FIRST SU]+3), #INVEST#:=1)
-----------------------------------------
RULE NUMBER: 156
IF:
      You have selected to investigate the [[UNIT_NOME]] range
further. Which
        of the following sub-units do you wish to investigate?
[[SU5]]
                [[SU5_AREA]][[SU5_AREA_U]]
  and   [SU5]<>""

THEN:
        FRAME("UN_COSTS", #NO#=([FIRST SU]+4), #INVEST#:=1)
-----------------------------------------
RULE NUMBER: 157
IF:
        You have selected to investigate the [[UNIT_NOME]] range
further. Which
        of the following sub-units do you wish to investigate?
[[SU6]]
                [[SU6_AREA]][[SU6_AREA_U]]
  and   [SU6]<>""

THEN:
        FRAME("UN_COSTS", #NO#=([FIRST SU]+5), #INVEST#:=1)
-----------------------------------------
RULE NUMBER: 158
IF:
        You have selected to investigate the [[UNIT_NOME]] range
further. Which
        of the following sub-units do you wish to investigate?
[[SU7]]
                [[SU7_AREA]][[SU7_AREA_U]]
  and   [SU7]<>""

THEN:
        FRAME("UN_COSTS", #NO#=([FIRST SU]+6), #INVEST#:=1)
-----------------------------------------
RULE NUMBER: 159
IF:
        You have selected to investigate the [[UNIT_NOME]] range
further. Which
        of the following sub-units do you wish to investigate?
[[SU8]]
```

```
                [[SU8_AREA]][[SU8_AREA_U]]
  and   [SU8]<>""

THEN:
        FRAME("UN_COSTS", #NO#=([FIRST SU]+7), #INVEST#:=1)
----------------------------------------
RULE NUMBER: 160
IF:
        You have selected to investigate the [[UNIT_NOME]] range
further. Which
        of the following sub-units do you wish to investigate?
[[SU9]]
                [[SU9_AREA]][[SU9_AREA_U]]
  and   [SU9]<>""

THEN:
        FRAME("UN_COSTS", #NO#=([FIRST SU]+8), #INVEST#:=1)
----------------------------------------
RULE NUMBER: 161
IF:
        You have selected to investigate the [[UNIT_NOME]] range
further. Which
        of the following sub-units do you wish to investigate?
[[SU10]]
                [[SU10_AREA]][[SU10_AREA_U]]
  and   [SU10]<>""

THEN:
        FRAME("UN_COSTS", #NO#=([FIRST SU]+9), #INVEST#:=1)
----------------------------------------
RULE NUMBER: 162
IF:
        You have selected to investigate the [[UNIT_NOME]] range
further. Which
        of the following sub-units do you wish to investigate?
[[SU11]]
                [[SU11_AREA]][[SU11_AREA_U]]
  and   [SU11]<>""

THEN:
        FRAME("UN_COSTS", #NO#=([FIRST SU]+10), #INVEST#:=1)
----------------------------------------
RULE NUMBER: 163
IF:
        You have selected to investigate the [[UNIT_NOME]] range
further. Which
        of the following sub-units do you wish to investigate?
[[SU12]]
                [[SU12_AREA]][[SU12_AREA_U]]
  and   [SU12]<>""

THEN:
      FRAME("UN_COSTS", #NO#=([FIRST SU]+11), #INVEST#:=1)
----------------------------------------
RULE NUMBER: 164
IF:
        You have selected to investigate the [[UNIT_NOME]] range
further. Which
        of the following sub-units do you wish to investigate?
[[SU13]]
                [[SU13_AREA]][[SU13_AREA_U]]
  and   [SU13]<>""

THEN:
        FRAME("UN_COSTS", #NO#=([FIRST SU]+12), #INVEST#:=1)
```

```
RULE NUMBER: 165
IF:
       You have selected to investigate the [[UNIT_NOME]] range
further. Which
       of the following sub-units do you wish to investigate?
[[SU14]]
                [[SU14_AREA]][[SU14_AREA_U]]
  and  [SU14]<>""

THEN:
       FRAME("UN_COSTS", #NO#=([FIRST SU]+13), #INVEST#:=1)
----------------------------------------
RULE NUMBER: 166
IF:
       You have selected to investigate the [[UNIT_NOME]] range
further. Which
       of the following sub-units do you wish to investigate?
[[SU15]]
                [[SU15_AREA]][[SU15_AREA_U]]
  and  [SU15]<>""

THEN:
       FRAME("UN_COSTS", #NO#=([FIRST SU]+14), #INVEST#:=1)
----------------------------------------
RULE NUMBER: 167
IF:
       [TYPE]=1
  and  [MT_NEED]>0

THEN:
       Material is needed
----------------------------------------
RULE NUMBER: 168
IF:
       [TYPE]=0
  and  [MT_NEED_SYS]>0

THEN:
       Material is needed
----------------------------------------
RULE NUMBER: 169
IF:
       [TYPE]=1
  and  [MT_NEED]=0

THEN:
       Material is not needed
----------------------------------------
RULE NUMBER: 170
IF:
       [TYPE]=0
  and  [MT_NEED_SYS]=0

THEN:
       Material is not needed
----------------------------------------
RULE NUMBER: 171
IF:
       Material is needed
  and  [MT_OWN]>0

THEN:
       Material is obtainable
```

```
RULE NUMBER: 172
IF:
        [TYPE]=1
  and   Material is needed
  and   [MT_PURCH]>0

THEN:
        Material is obtainable
  and     [MAT  COST]  IS  GIVEN  THE  VALUE  ([MAT  COST]  +
([MT_NEED]*[MT_PURCH]))
-----------------------------------------
RULE NUMBER: 173
IF:
        [TYPE]=0
  and   Material is needed
  and   [MT_PURCH]>0

THEN:
        Material is obtainable
  and     [MAT  COST]  IS  GIVEN  THE  VALUE  ([MAT  COST]  +
([MT_NEED_SYS]*[MT_PURCH]))
-----------------------------------------
RULE NUMBER: 174
IF:
        Material is needed
  and   [MT_NO]>0

THEN:
        Material is not obtainable
-----------------------------------------
RULE NUMBER: 175
IF:
        Material is needed
  and   [MT_OWN]=0
  and   [MT_PURCH]=0
  and   [MT_NO]=0

THEN:
        [MM] IS GIVEN THE VALUE 1
-----------------------------------------
RULE NUMBER: 176
IF:
        [[MAT NOME]]/s   is/are owned or obtainable i.e. zero
charge OR
        purchaseable OR not obtainable

THEN:
        Information on material availability is not required

ELSE:
        DISPLAY(MAT[[COUNT]].INF)
  and   CLEAR(Q 50)
  and   CLEAR(R THIS)
-----------------------------------------
RULE NUMBER: 177
IF:
        Information on material availability is not required
  and    [[MAT NOME]]/s   is/are owned or obtainable i.e. zero
charge OR
        purchaseable

THEN:
        Commence materials? Yes

ELSE:
        Material is not obtainable
```

```
  and  FRAME("MT_EUINF", #MT#=[COUNT], #NO#:=1)
----------------------------------------
RULE NUMBER: 178
IF:
       Commence materials? Yes
  and   [[MAT NOME]]/s  is/are owned or obtainable i.e. zero
charge

THEN:
       Material is obtainable
  and  FRAME("MT_EUINF", #MT#=[COUNT], #OWN#:=1)
----------------------------------------
RULE NUMBER: 179
IF:
       Commence materials? Yes
  and  [TYPE]=1
  and  [[MAT NOME]]/s  is/are purchaseable

THEN:
       Material is obtainable
  and       [MAT   COST]   IS   GIVEN   THE   VALUE   ([MAT
COST]+([MAT_PURCHASE]*[MT_NEED]))
  and  FRAME("MT_EUINF", #MT#=[COUNT], #PURCH#:=[MAT_PURCHASE])
----------------------------------------
RULE NUMBER: 180
IF:
       Commence materials? Yes
  and  [TYPE]=0
  and  [[MAT NOME]]/s  is/are purchaseable

THEN:
       Material is obtainable
  and  [MAT COST] IS GIVEN THE VALUE ([MAT
       COST]+([MAT_PURCHASE]*[MT_NEED_SYS]))
  and  FRAME("MT_EUINF", #MT#=[COUNT], #PURCH#:=[MAT_PURCHASE])
----------------------------------------
RULE NUMBER: 181
IF:
       Material is needed
  and  Material is not obtainable

THEN:
       [COUNT] IS GIVEN THE VALUE [MAT_NUM]
  and  [MAT COST] IS GIVEN THE VALUE 999999

ELSE:
       [COUNT] IS GIVEN THE VALUE ([COUNT]+1)
----------------------------------------
RULE NUMBER: 182
IF:
       [MAT COST]<>999999
  and  [TYPE]=1

THEN:
       [MAT  COST  FCD]  IS  GIVEN  THE  VALUE  ([MAT  COST]  *
[UN_MAT_FAC])
  and  FRAME("UN_COSTS", #NO#=[U], #MATER#:=[MAT COST FCD])
  and  FRAME("UN_COSTS", #NO#=[U], #FAC_ROW#:=[FAC_ROW_NO])
  and  FRAME("RUN_DATA", #NO#=[FAC_ROW_NO], #MAT#:=[UN_MAT_FAC])
----------------------------------------
RULE NUMBER: 183
IF:
       [MAT COST]<>999999
  and  [TYPE]=0

THEN:
```

```
       [MAT COST FCD] IS GIVEN THE VALUE ([MAT COST] *
[SY_MAT_FAC])
  and  FRAME("SY_COSTS", #RS#=[RS_NO_ACC], #MATER#:=[MAT COST
FCD])
  and       FRAME("SY_COSTS",    #RS#=[RS_NO_ACC],
#FAC_ROW#:=[FAC_ROW_NO])
  and FRAME("RUN_DATA", #NO#=[FAC_ROW_NO], #MAT#:=[SY_MAT_FAC])
-----------------------------------------
RULE NUMBER: 184
IF:
       [TYPE]=1
  and  [MD_NEED]>0

THEN:
       Module is needed
-----------------------------------------
RULE NUMBER: 185
IF:
       [TYPE]=0
  and  [MD_NEED_SYS]>0

THEN:
       Module is needed
-----------------------------------------
RULE NUMBER: 186
IF:
       [TYPE]=1
  and  [MD_NEED]=0

THEN:
       Module is not needed
-----------------------------------------
RULE NUMBER: 187
IF:
       [TYPE]=0
  and  [MD_NEED_SYS]=0

THEN:
       Module is not needed
-----------------------------------------
RULE NUMBER: 188
IF:
       Module is needed
  and  [MD_OWN]>0

THEN:
       Module is obtainable
-----------------------------------------
RULE NUMBER: 189
IF:
       [TYPE]=1
  and  Module is needed
  and  [MD_PURCH]>0

THEN:
       Module is obtainable
  and     [MOD COST] IS GIVEN THE VALUE ([MOD COST] +
([MD_PURCH]*[MD_NEED]))
-----------------------------------------
RULE NUMBER: 190
IF:
       [TYPE]=0
  and  Module is needed
  and  [MD_PURCH]>0

THEN:
```

```
        Module is obtainable
  and     [MOD  COST]  IS  GIVEN  THE  VALUE  ([MOD  COST]  +
([MD_PURCH]*[MD_NEED_SYS]))
----------------------------------------
RULE NUMBER: 191
IF:
        Module is needed
  and   [MD_NO]>0

THEN:
        Module is not obtainable
----------------------------------------
RULE NUMBER: 192
IF:
        Module is needed
  and   [MD_OWN]=0
  and   [MD_PURCH]=0
  and   [MD_NO]=0

THEN:
        [OO] IS GIVEN THE VALUE 1
----------------------------------------
RULE NUMBER: 193
IF:
        [[MOD NOME]] is/are owned or obtainable free of charge OR
purchaseable
        OR not obtainable

THEN:
        Info on modules available is not reqd

ELSE:
        DISPLAY(MOD[[COUNT]].INF)
  and   CLEAR(Q 55)
  and   CLEAR(R THIS)
----------------------------------------
RULE NUMBER: 194
IF:
        Info on modules available is not reqd
  and   [[MOD NOME]] is/are owned or obtainable free of charge OR
purchaseable

THEN:
        Commence modules? Yes

ELSE:
        Module is not obtainable
  and   FRAME("MD_EUINF", #MD#=[COUNT], #NO#:=1)
----------------------------------------
RULE NUMBER: 195
IF:
        Commence modules? Yes
  and   [[MOD NOME]] is/are owned or obtainable free of charge

THEN:
        Module is obtainable
  and   FRAME("MD_EUINF", #MD#=[COUNT], #OWN#:=1)
----------------------------------------
RULE NUMBER: 196
IF:
        Commence modules? Yes
  and   [TYPE]=1
  and   [[MOD NOME]] is/are purchaseable

THEN:
        Module is obtainable
```

```
  and     [MOD  COST]  IS  GIVEN  THE  VALUE  ([MOD  COST]  +
([MOD_PURCHASE]*[MD_NEED]))
  and  FRAME("MD_EUINF", #MD#=[COUNT], #PURCH#:=[MOD_PURCHASE])
----------------------------------------
RULE NUMBER: 197
IF:
        Commence modules? Yes
  and   [TYPE]=0
  and   [[MOD NOME]] is/are purchaseable

THEN:
        Module is obtainable
  and   [MOD COST] IS GIVEN THE VALUE ([MOD COST] +
        ([MOD PURCHASE]*[MD_NEED_SYS]))
  and  FRAME("MD_EUINF", #MD#=[COUNT], #PURCH#:=[MOD_PURCHASE])
----------------------------------------
RULE NUMBER: 198
IF:
        Module is needed
  and   Module is not obtainable

THEN:
        [COUNT] IS GIVEN THE VALUE [CURRENT_MOD_NUM]
  and   [MOD COST] IS GIVEN THE VALUE 999999

ELSE:
        [COUNT] IS GIVEN THE VALUE ([COUNT]+1)
----------------------------------------
RULE NUMBER: 199
IF:
        [TYPE]=0
  and   [CAT]="S"

THEN:
        [SY_CAT] IS GIVEN THE VALUE "SELF"

ELSE:
        [SY_CAT] IS GIVEN THE VALUE "PURCH"
----------------------------------------
RULE NUMBER: 200
IF:
        [TYPE]=1
  and   How would you best describe yourself? ^^Small scale
contractor^^

THEN:
        [UN_CAT] IS GIVEN THE VALUE "CONT"
----------------------------------------
RULE NUMBER: 201
IF:
        [TYPE]=1
  and   How would you best describe yourself? Artisan

THEN:
        [UN_CAT] IS GIVEN THE VALUE "ART"
----------------------------------------
RULE NUMBER: 202
IF:
        [TYPE]=1
  and   How would you best describe yourself? ^^Self-builder^^

THEN:
        [UN_CAT] IS GIVEN THE VALUE "SELF"
```

```
RULE NUMBER: 203
IF:
        [MOD COST]<>999999
  and   [TYPE]=1

THEN:
        [MOD COST FCD] IS GIVEN THE VALUE ([MOD COST] *
[UN_MOD_FAC])
  and   FRAME("UN_COSTS", #NO#=[U], #MODUL#:=[MOD COST FCD])
  and   FRAME("UN_COSTS", #NO#=[U], #FAC_ROW#:=[FAC_ROW_NO])
  and   FRAME("RUN_DATA", #NO#=[FAC_ROW_NO], #MOD#:=[UN_MOD_FAC])
-----------------------------------------
RULE NUMBER: 204
IF:
        [MOD COST]<>999999
  and   [TYPE]=0

THEN:
        [MOD COST FCD] IS GIVEN THE VALUE ([MOD COST] *
[SY_MOD_FAC])
  and   FRAME("SY_COSTS", #RS#=[RS_NO_ACC], #MODUL#:=[MOD COST
FCD])
  and   FRAME("SY_COSTS", #RS#=[RS_NO_ACC],
#FAC_ROW#:=[FAC_ROW_NO])
  and   FRAME("RUN_DATA", #NO#=[FAC_ROW_NO], #MOD#:=[SY_MOD_FAC])
-----------------------------------------
RULE NUMBER: 205
IF:
        [TYPE]=1
  and   [EQ_HOURS]>0

THEN:
        Equipment is needed
-----------------------------------------
RULE NUMBER: 206
IF:
        [TYPE]=0
  and   [EQ_HOURS_SYS]>0

THEN:
        Equipment is needed
-----------------------------------------
RULE NUMBER: 207
IF:
        [TYPE]=1
  and   [EQ_HOURS]=0

THEN:
        Equipment is not needed
-----------------------------------------
RULE NUMBER: 208
IF:
        [TYPE]=0
  and   [EQ_HOURS_SYS]=0

THEN:
        Equipment is not needed
-----------------------------------------
RULE NUMBER: 209
IF:
        Equipment is needed
  and   [EQ_OWN]>0

THEN:
        Equipment is obtainable
```

```
RULE NUMBER: 210
IF:
        [TYPE]=1
  and   Equipment is needed
  and   [EQ_PURCH]>0

THEN:
        Equipment is obtainable
  and     [EQUIP COST] IS GIVEN THE VALUE ([EQUIP COST] +
([EQ_PURCH]*[EQ_NO]))
-----------------------------------------
RULE NUMBER: 211
IF:
        [TYPE]=0
  and   Equipment is needed
  and   [EQ_PURCH]>0

THEN:
        Equipment is obtainable
  and   [EQUIP COST] IS GIVEN THE VALUE ([EQUIP COST] +
        ([EQ_PURCH]*[EQ_NO_SYS]))
-----------------------------------------
RULE NUMBER: 212
IF:
        [TYPE]=1
  and   Equipment is needed
  and   [EQ_RENT_DAY]>0

THEN:
        Equipment is obtainable
  and   [EQUIP COST] IS GIVEN THE VALUE ([EQUIP COST] +
        ([EQ_RENT_DAY]*[EQ_NO]*[EQ_DAYS]))
-----------------------------------------
RULE NUMBER: 213
IF:
        [TYPE]=0
  and   Equipment is needed
  and   [EQ_RENT_DAY]>0

THEN:
        Equipment is obtainable
  and   [EQUIP COST] IS GIVEN THE VALUE ([EQUIP COST] +
        ([EQ_RENT_DAY]*[EQ_NO_SYS]*[EQ_DAYS_SYS]))
-----------------------------------------
RULE NUMBER: 214
IF:
        [TYPE]=1
  and   Equipment is needed
  and   [EQ_RENT_HOUR]>0

THEN:
        Equipment is obtainable
  and   [EQUIP COST] IS GIVEN THE VALUE ([EQUIP COST] +
        ([EQ_RENT_HOUR]*[EQ_NO]*[EQ_HOURS]))
-----------------------------------------
RULE NUMBER: 215
IF:
        [TYPE]=0
  and   Equipment is needed
  and   [EQ_RENT_HOUR]>0

THEN:
        Equipment is obtainable
  and   [EQUIP COST] IS GIVEN THE VALUE ([EQUIP COST] +
        ([EQ_RENT_HOUR]*[EQ_NO_SYS]*[EQ_HOURS_SYS]))
```

```
RULE NUMBER: 216
IF:
        Equipment is needed
  and   [EQ_NOO]>0

THEN:
        Equipment is not obtainable
----------------------------------------
RULE NUMBER: 217
IF:
        Equipment is needed
  and   [EQ_OWN]=0
  and   [EQ_PURCH]=0
  and   [EQ_RENT_DAY]=0
  and   [EQ_RENT_HOUR]=0
  and   [EQ_NOO]=0

THEN:
        [EE] IS GIVEN THE VALUE 1
----------------------------------------
RULE NUMBER: 218
IF:
        [[EQUIP NOME]]/s   is/are owned or obtainable free of
charge OR
        purchaseable OR rentable  OR not obtainable

THEN:
        Information on equipment availability is not required

ELSE:
        DISPLAY(EQUIP[[COUNT]].INF)
  and   CLEAR(Q 60)
  and   CLEAR(R THIS)
----------------------------------------
RULE NUMBER: 219
IF:
        Information on equipment availability is not required
  and    [[EQUIP NOME]]/s   is/are owned or obtainable free of
charge OR
        purchaseable OR rentable

THEN:
        Commence equipment? Yes

ELSE:
        Equipment is not obtainable
  and   FRAME("EQ_EUINF", #EQ#=[COUNT], #NO#:=1)
----------------------------------------
RULE NUMBER: 220
IF:
        Commence equipment? Yes
  and    [[EQUIP NOME]]/s   is/are owned or obtainable free of
charge

THEN:
        Equipment is obtainable
  and   FRAME("EQ_EUINF", #EQ#=[COUNT], #OWN#:=1)
----------------------------------------
RULE NUMBER: 221
IF:
        [TYPE]=1
  and   Commence equipment? Yes
  and   [[EQUIP NOME]]/s  is/are purchaseable

THEN:
        Equipment is obtainable
```

```
  and   [EQUIP COST] IS GIVEN THE VALUE ([EQUIP COST] +
        ([EQUIP PURCHASE]*[EQ NO]))
  and  FRAME("EQ_EUINF", #EQ#=[COUNT], #PURCH#:=[EQUIP_PURCHASE])
-----------------------------------------
RULE NUMBER: 222
IF:
        [TYPE]=0
  and   Commence equipment? Yes
  and   [[EQUIP NOME]]/s  is/are purchaseable

THEN:
        Equipment is obtainable
  and   [EQUIP COST] IS GIVEN THE VALUE ([EQUIP COST] +
        ([EQUIP_PURCHASE]*[EQ_NO_SYS]))
  and  FRAME("EQ_EUINF", #EQ#=[COUNT], #PURCH#:=[EQUIP_PURCHASE])
-----------------------------------------
RULE NUMBER: 223
IF:
        [TYPE]=1
  and   Commence equipment? Yes
  and   [[EQUIP NOME]]/s  is/are rentable
  and   Renting of [[EQUIP NOME]] is done on a daily basis OR not
known

THEN:
        Equipment is obtainable
  and   [EQUIP COST] IS GIVEN THE VALUE ([EQUIP
        COST]+([EQUIP_RENT_D]*[EQ_DAYS]*[EQ_NO]))
  and  FRAME("EQ_EUINF", #EQ#=[COUNT], #RENT-D#:=[EQUIP_RENT_D])
-----------------------------------------
RULE NUMBER: 224
IF:
        [TYPE]=0
  and   Commence equipment? Yes
  and   [[EQUIP NOME]]/s  is/are rentable
  and   Renting of [[EQUIP NOME]] is done on a daily basis OR not
known

THEN:
        Equipment is obtainable
  and   [EQUIP COST] IS GIVEN THE VALUE ([EQUIP
        COST]+([EQUIP_RENT_D]*[EQ_DAYS_SYS]*[EQ_NO_SYS]))
  and  FRAME("EQ_EUINF", #EQ#=[COUNT], #RENT-D#:=[EQUIP_RENT_D])
-----------------------------------------
RULE NUMBER: 225
IF:
        [TYPE]=1
  and   Commence equipment? Yes
  and   [[EQUIP NOME]]/s  is/are rentable
  and   Renting of [[EQUIP NOME]] is done on a hourly basis

THEN:
        Equipment is obtainable
  and   [EQUIP COST] IS GIVEN THE VALUE ([EQUIP
        COST]+([EQUIP_RENT_H]*[EQ_HOURS]*[EQ_NO]))
  and  FRAME("EQ_EUINF", #EQ#=[COUNT], #RENT-H#:=[EQUIP_RENT_H])
-----------------------------------------
RULE NUMBER: 226
IF:
        [TYPE]=0
  and   Commence equipment? Yes
  and   [[EQUIP NOME]]/s  is/are rentable
  and   Renting of [[EQUIP NOME]] is done on a hourly basis

THEN:
        Equipment is obtainable
```

```
  and   [EQUIP COST] IS GIVEN THE VALUE ([EQUIP
        COST]+([EQUIP RENT H]*[EQ HOURS SYS]*[EQ NO SYS]))
  and FRAME("EQ_EUINF", #EQ#=[COUNT], #RENT-H#:=[EQUIP_RENT_H])
-----------------------------------------
RULE NUMBER: 227
IF:
       Equipment is needed
  and  Equipment is not obtainable

THEN:
       [COUNT] IS GIVEN THE VALUE [EQUIP_NUM]
  and  [EQUIP COST] IS GIVEN THE VALUE 999999

ELSE:
       [COUNT] IS GIVEN THE VALUE ([COUNT]+1)
-----------------------------------------
RULE NUMBER: 228
IF:
       [EQUIP COST]<>999999
  and  [TYPE]=0

THEN:
       [EQUIP COST FCD] IS GIVEN THE VALUE ([EQUIP COST] *
[SY_EQUIP_FAC])
  and  FRAME("SY_COSTS", #RS#=[RS_NO_ACC], #EQUIP#:=[EQUIP COST
FCD])
   and        FRAME("SY_COSTS",    #RS#=[RS_NO_ACC],
#FAC_ROW#=[FAC_ROW_NO])
   and        FRAME("RUN_DATA",    #NO#=[FAC_ROW_NO],
#EQUIP#:=[SY_EQUIP_FAC])
-----------------------------------------
RULE NUMBER: 229
IF:
       [EQUIP COST]<>999999
  and  [TYPE]=1

THEN:
       [EQUIP COST FCD] IS GIVEN THE VALUE ([EQUIP COST] *
[UN_EQUIP_FAC])
  and  FRAME("UN_COSTS", #NO#=[U], #EQUIP#:=[EQUIP COST FCD])
  and  FRAME("UN_COSTS", #NO#=[U], #FAC_ROW#=[FAC_ROW_NO])
   and        FRAME("RUN_DATA",    #NO#=[FAC_ROW_NO],
#EQUIP#:=[UN_EQUIP_FAC])
-----------------------------------------
RULE NUMBER: 230
IF:
       [TYPE]=1
  and  [TL_HOURS]>0

THEN:
       Tool is needed
-----------------------------------------
RULE NUMBER: 231
IF:
       [TYPE]=0
  and  [TL_HOURS_SYS]>0

THEN:
       Tool is needed
-----------------------------------------
```

```
RULE NUMBER: 232
IF:
        [TYPE]=1
  and   [TL_HOURS]=0

THEN:
        Tool is not needed
-----------------------------------------
RULE NUMBER: 233
IF:
        [TYPE]=0
  and   [TL_HOURS_SYS]=0

THEN:
        Tool is not needed
-----------------------------------------
RULE NUMBER: 234
IF:
        Tool is needed
  and   [OWN]>0

THEN:
        Tool is obtainable
-----------------------------------------
RULE NUMBER: 235
IF:
        Tool is needed
  and   [TYPE]=1
  and   [PURCH]>0

THEN:
        [TOOL    COST]    IS    GIVEN    THE    VALUE    ([TOOL
COST]+([PURCH]*[TL_NO]))
  and   Tool is obtainable
-----------------------------------------
RULE NUMBER: 236
IF:
        Tool is needed
  and   [TYPE]=0
  and   [PURCH]>0

THEN:
        [TOOL    COST]    IS    GIVEN    THE    VALUE    ([TOOL
COST]+([PURCH]*[TL_NO_SYS]))
  and   Tool is obtainable
-----------------------------------------
RULE NUMBER: 237
IF:
        Tool is needed
  and   [TYPE]=1
  and   [RENT_DAY]>0

THEN:
        [TOOL COST] IS GIVEN THE VALUE ([TOOL
        COST]+([RENT_DAY]*[TL_DAYS]*[TL_NO]))
  and   Tool is obtainable
-----------------------------------------
RULE NUMBER: 238
IF:
        Tool is needed
  and   [TYPE]=0
  and   [RENT_DAY]>0

THEN:
        [TOOL COST] IS GIVEN THE VALUE ([TOOL
        COST]+([RENT_DAY]*[TL_DAYS_SYS]*[TL_NO_SYS]))
```

```
  and  Tool is obtainable
----------------------------------------
RULE NUMBER: 239
IF:
       Tool is needed
  and  [TYPE]=1
  and  [RENT_HOUR]>0

THEN:
       [TOOL COST] IS GIVEN THE VALUE ([TOOL
       COST]+([RENT_HOUR]*[TL_HOURS]*[TL_NO]))
  and  Tool is obtainable
----------------------------------------
RULE NUMBER: 240
IF:
       Tool is needed
  and  [TYPE]=0
  and  [RENT_HOUR]>0

THEN:
       [TOOL COST] IS GIVEN THE VALUE ([TOOL
       COST]+([RENT_HOUR]*[TL_HOURS_SYS]*[TL_NO_SYS]))
  and  Tool is obtainable
----------------------------------------
RULE NUMBER: 241
IF:
       Tool is needed
  and  [NO]>0

THEN:
       Tool is not obtainable
----------------------------------------
RULE NUMBER: 242
IF:
       Tool is needed
  and  [OWN]=0
  and  [PURCH]=0
  and  [RENT_DAY]=0
  and  [RENT_HOUR]=0
  and  [NO]=0

THEN:
       [TT] IS GIVEN THE VALUE 1
----------------------------------------
RULE NUMBER: 243
IF:
       Is/are a/any [[TOOL NOME]]/s: owned or borrowable i.e.
zero cost OR
       purchaseable OR rentable OR not obtainable

THEN:
       Information on tool availability is not required

ELSE:
       DISPLAY(TOOL[[COUNT]].INF)
  and  CLEAR(Q 19)
  and  CLEAR(R THIS)
----------------------------------------
RULE NUMBER: 244
IF:
       Information on tool availability is not required
  and  Is/are a/any [[TOOL NOME]]/s: owned or borrowable i.e.
zero cost OR
       purchaseable OR rentable

THEN:
```

```
        Commence tools yes

ELSE:
        Tool is not obtainable
  and   FRAME("TL_EUINF", #TL#=[COUNT], #NO#:=1)
-----------------------------------------
RULE NUMBER: 245
IF:
        Commence tools yes
  and   Is/are a/any [[TOOL NOME]]/s: owned or borrowable i.e.
zero cost

THEN:
        Tool is obtainable
  and   FRAME("TL_EUINF", #TL#=[COUNT], #OWN#:=1)
-----------------------------------------
RULE NUMBER: 246
IF:
        Commence tools yes
  and   [TYPE]=1
  and   Is/are a/any [[TOOL NOME]]/s: purchaseable

THEN:
        Tool is obtainable
  and     [TOOL  COST]  IS  GIVEN  THE  VALUE  ([TOOL  COST]  +
([PURCHASE]*[TL_NO]))
  and   FRAME("TL_EUINF", #TL#=[COUNT], #PURCH#:=[PURCHASE])
-----------------------------------------
RULE NUMBER: 247
IF:
        Commence tools yes
  and   [TYPE]=0
  and   Is/are a/any [[TOOL N ME]]/s: purchaseable

THEN:
        Tool is obtainable
  and     [TOOL  COST]  IS  GIVEN  THE  VALUE  ([TOOL  COST]  +
([PURCHASE]*[TL_NO_SYS]))
  and   FRAME("TL_EUINF", #TL#=[COUNT], #PURCH#:=[PURCHASE])
-----------------------------------------
RULE NUMBER: 248
IF:
        Commence tools yes
  and   [TYPE]=1
  and   Is/are a/any [[TOOL NOME]]/s: rentable
  and   Renting of the [[TOOL NOME]]/s is done on a daily basis
OR not known

THEN:
        Tool is obtainable
  and   [TOOL COST] IS GIVEN THE VALUE ([TOOL COST] +
        ([RENT_D]*[TL_DAYS]*[TL_NO]))
  and   FRAME("TL_EUINF", #TL#=[COUNT], #RENT-D#:=[RENT_D])
-----------------------------------------
RULE NUMBER: 249
IF:
        Commence tools yes
  and   [TYPE]=0
  and   Is/are a/any [[TOOL NOME]]/s: rentable
  and   Renting of the [[TOOL NOME]]/s is done on a daily basis
OR not known

THEN:
        Tool is obtainable
  and   [TOOL COST] IS GIVEN THE VALUE ([TOOL COST] +
        ([RENT_D]*[TL_DAYS_SYS]*[TL_NO_SYS]))
```

```
  and  FRAME("TL_EUINF", #TL#=[COUNT], #RENT-D#:=[RENT_D])
----------------------------------------
RULE NUMBER: 250
IF:
       Commence tools yes
  and  [TYPE]=1
  and  Is/are a/any [[TOOL NOME]]/s: rentable
  and  Renting of the [[TOOL NOME]]/s is don  n an hourly basis

THEN:
       Tool is obtainable
  and  [TOOL COST] IS GIVEN THE VALUE ([TOOL COST] +
       ([RENT_H]*[TL_HOURS]*[TL_NO]))
  and  FRAME("TL_EUINF", #TL#=[COUNT], #RENT-H#:=[RENT_H])
----------------------------------------
RULE NUMBER: 251
IF:
       Commence tools yes
  and  [TYPE]=0
  and  Is/are a/any [[TOOL NOME]]/s: rentable
  and  Renting of the [[TOOL NOME]]/s is done on an hourly basis

THEN:
       Tool is obtainable
  and  [TOOL COST] IS GIVEN THE VALUE ([TOOL COST] +
       ([RENT_H]*[TL_HOURS_SYS]*[TL_NO_SYS]))
  and  FRAME("TL_EUINF", #TL#=[COUNT], #RENT-H#:=[RENT_H])
----------------------------------------
RULE NUMBER: 252
IF:
       Tool is needed
  and  Tool is not obtainable

THEN:
       [COUNT] IS GIVEN THE VALUE ([TOOL_NUM])
  and  [TOOL COST] IS GIVEN THE VALUE 999999

ELSE:
       [COUNT] IS GIVEN THE VALUE [COUNT]+1
----------------------------------------
RULE NUMBER: 253
IF:
       [TOOL COST]<>999999
  and  [TYPE]=0

THEN:
       [TOOL COST FCD] IS GIVEN THE VALUE ([TOOL COST] *
[SY_TOOL_FAC])
  and  FRAME("SY_COSTS", #RS#=[RS_NO_ACC], #TOOLS#:=[TOOL COST
FCD])
  and        FRAME("SY_COSTS",    #RS#=[RS_NO_ACC],
#FAC_ROW#:=[FAC_ROW_NO])
  and        FRAME("RUN_DATA",    #NO#=[FAC_ROW_NO],
#TOOL#:=[SY_TOOL_FAC])
----------------------------------------
RULE NUMBER: 254
IF:
       [TOOL COST]<>999999
  and  [TYPE]=1

THEN:
       [TOOL COST FCD] IS GIVEN THE VALUE ([TOOL COST] *
[UN_TOOL_FAC])
  and  FRAME("UN_COSTS", #NO#=[U], #TOOLS#:=[TOOL COST FCD])
  and  FRAME("UN_COSTS", #NO#=[U], #FAC_ROW#:=[FAC_ROW_NO])
  and        FRAME("RUN_DATA",    #NO#=[FAC_ROW_NO],
```

```
#TOOL#:=[UN_TOOL_FAC])
-----------------------------------------
RULE NUMBER: 255
IF:
        [TYPE]=1
  and   [LB_HOURS]>0

THEN:
        Labour is needed
-----------------------------------------
RULE NUMBER: 256
IF:
        [TYPE]=0
  and   [LB_HOURS_SYS]>0

THEN:
        Labour is needed
-----------------------------------------
RULE NUMBER: 257
IF:
        [TYPE]=1
  and   [LB_HOURS]=0

THEN:
        Labour is not needed
-----------------------------------------
RULE NUMBER: 258
IF:
        [TYPE]=0
  and   [LB_HOURS_SYS]=0

THEN:
        Labour is not needed
-----------------------------------------
RULE NUMBER: 259
IF:
        Labour is needed
  and   [LB_OWN]>0

THEN:
        Labour is  obtainable
-----------------------------------------
RULE NUMBER: 260
IF:
        Labour is needed
  and   [TYPE]=1
  and   [LB_RENT_DAY]>0

THEN:
        Labour is  obtainable
  and   [LAB COST] IS GIVEN THE VALUE ([LAB COST] +
        ([LB_RENT_DAY]*[LB_DAYS]*[LB_NO]))
-----------------------------------------
RULE NUMBER: 261
IF:
        Labour is needed
  and   [TYPE]=0
  and   [LB_RENT_DAY]>0

THEN:
        Labour is  obtainable
  and   [LAB COST] IS GIVEN THE VALUE ([LAB COST] +
        ([LB_RENT_DAY]*[LB_DAYS_SYS]*[LB_NO_SYS]))
-----------------------------------------
```

```
RULE NUMBER: 262
IF:
        Labour is needed
  and   [TYPE]=1
  and   [LB_RENT_HOUR]>0

THEN:
        Labour is  obtainable
  and   [LAB COST] IS GIVEN THE VALUE ([LAB COST] +
        ([LB_RENT_HOUR]*[LB_HOURS]*[LB_NO]))
-----------------------------------------
RULE NUMBER: 263
IF:
        Labour is needed
  and   [TYPE]=0
  and   [LB_RENT_HOUR]>0

THEN:
        Labour is  obtainable
  and   [LAB COST] IS GIVEN THE VALUE ([LAB COST] +
        ([LB_RENT_HOUR]*[LB_HOURS_SYS]*[LB_NO_SYS]))
-----------------------------------------
RULE NUMBER: 264
IF:
        Labour is needed
  and   [LB_NOO]>0

THEN:
        Labour is not obtainable
-----------------------------------------
RULE NUMBER: 265
IF:
        Labour is needed
  and   [LB_OWN]=0
  and   [LB_RENT_DAY]=0
  and   [LB_RENT_HOUR]=0
  and   [LB_NOO]=0

THEN:
        [LL] IS GIVEN THE VALUE 1
-----------------------------------------
RULE NUMBER: 266
IF:
        [[LAB NOME]] labourers are obtainable free of charge OR
rentable OR not
        obtainable

THEN:
        Information on labour availability is not reqd

ELSE:
        DISPLAY(LAB[[COUNT]].INF)
  and   CLEAR(Q 66)
  and   CLEAR(R THIS)
-----------------------------------------
RULE NUMBER: 267
IF:
        Information on labour availability is not reqd
  and   [[LAB NOME]] labourers are obtainable free of charge OR
rentable

THEN:
        Commence labour? Yes

ELSE:
        Labour is not obtainable
```

```
  and  FRAME("LB_EUINF", #LB#=[COUNT], #NO#:=1)
-----------------------------------------
RULE NUMBER: 268
IF:
       Commence labour? Yes
  and  [[LAB NOME]] labourers are obtainable free of charge

THEN:
       Labour is  obtainable
  and  FRAME("LB_EUINF", #LB#=[COUNT], #OWN#:=1)
-----------------------------------------
RULE NUMBER: 269
IF:
       Commence labour? Yes
  and  [TYPE]=1
  and  [[LAB NOME]] labourers are rentable
  and  Renting of [[LAB NOME]] labour is done on a daily basis
OR not known

THEN:
       Labour is  obtainable
  and  [LAB COST] IS GIVEN THE VALUE ([LAB COST]
       +([LAB_RENT_D]*[LB_DAYS]*[LB_NO]))
  and  FRAME("LB_EUINF", #LB#=[COUNT], #RENT-D#:=[LAB_RENT_D])
-----------------------------------------
RULE NUMBER: 270
IF:
       Commence labour? Yes
  and  [TYPE]=0
  and  [[LAB NOME]] labourers are rentable
  and  Renting of [[LAB NOME]] labour is done on a daily basis
OR not known

THEN:
       Labour is  obtainable
  and  [LAB COST] IS GIVEN THE VALUE ([LAB COST]
       +([LAB_RENT_D]*[LB_DAYS_SYS]*[LB_NO_SYS]))
  and  FRAME("LB_EUINF", #LB#=[COUNT], #RENT-D#:=[LAB_RENT_D])
-----------------------------------------
RULE NUMBER: 271
IF:
       Commence labour? Yes
  and  [TYPE]=1
  and  [[LAB NOME]] labourers are rentable
  and  Renting of [[LAB NOME]] labour is done on an hourly basis

THEN:
       Labour is  obtainable
  and  [LAB COST] IS GIVEN THE VALUE ([LAB COST]
       +([LAB_RENT_H]*[LB_HOURS]*[LB_NO]))
  and  FRAME("LB_EUINF", #LB#=[COUNT], #RENT-H#:=[LAB_RENT_H])
-----------------------------------------
RULE NUMBER: 272
IF:
       Commence labour? Yes
  and  [TYPE]=0
  and  [[LAB NOME]] labourers are rentable
  and  Renting of [[LAB NOME]] labour is done on an hourly basis

THEN:
       Labour is  obtainable
  and  [LAB COST] IS GIVEN THE VALUE ([LAB COST]
       +([LAB_RENT_H]*[LB_HOURS_SYS]*[LB_NO_SYS]))
  and  FRAME("LB_EUINF", #LB#=[COUNT], #RENT-H#:=[LAB_RENT_H])
```

```
RULE NUMBER: 273
IF:
        Labour is needed
  and   Labour is not obtainable

THEN:
        [COUNT] IS GIVEN THE VALUE [LAB_NUM]
  and   [LAB COST] IS GIVEN THE VALUE 999999

ELSE:
        [COUNT] IS GIVEN THE VALUE ([COUNT]+1)
-----------------------------------------
RULE NUMBER: 274
IF:
        [LAB COST]<>999999
  and   [TYPE]=1

THEN:
        [LAB COST FCD] IS GIVEN THE VALUE ([LAB COST] *
[UN_LAB_FAC])
  and   FRAME("UN_COSTS", #NO#=[U], #LABOR#:=[LAB COST FCD])
  and   FRAME("UN_COSTS", #NO#=[U], #FAC_ROW#:=[FAC_ROW_NO])
  and  FRAME("RUN_DATA", #NO#=[FAC_ROW_NO], #LAB#:=[UN_LAB_FAC])
  and   [FAC_ROW_NO1] IS GIVEN THE VALUE ([FAC_ROW_NO]+1)
   and        FRAME("NUMBERS.FRM",    $ITEM$="Factors",
#NUM#:=[FAC_ROW_NO1])
-----------------------------------------
RULE NUMBER: 275
IF:
        [LAB COST]<>999999
  and   [TYPE]=0

THEN:
        [LAB COST FCD] IS GIVEN THE VALUE ([LAB COST] *
[SY_LAB_FAC])
  and   FRAME("SY_COSTS", #RS#=[RS_NO_ACC], #LABOR#:=[LAB COST
FCD])
   and        FRAME("SY_COSTS",    #RS#=[RS_NO_ACC],
#FAC_ROW#:=[FAC_ROW_NO])
  and  FRAME("RUN_DATA", #NO#=[FAC_ROW_NO], #LAB#:=[SY_LAB_FAC])
  and   [FAC_ROW_NO1] IS GIVEN THE VALUE ([FAC_ROW_NO]+1)
   and        FRAME("NUMBERS.FRM",    $ITEM$="Factors",
#NUM#:=[FAC_ROW_NO1])
-----------------------------------------
RULE NUMBER: 276
IF:
        [MAT COST]>=0
  and   [MOD COST]>=0
  and   [TOOL COST]>=0
  and   [EQUIP COST]>=0
  and   [LAB COST]>=0

THEN:
        [TOTAL COST] IS GIVEN THE VALUE ([MAT COST FCD]+[MOD COST
FCD]+[TOOL
        COST FCD]+[EQUIP COST FCD]+[LAB COST FCD])
-----------------------------------------
RULE NUMBER: 277
IF:
        [TYPE]=1
  and   [FIN_AVAIL]>=[TOTAL COST]

THEN:
        FRAME("UN_COSTS", #NO#=[U], $FINAL$:="Yes")
  and   FRAME("UN_COSTS", #NO#=[U], #TOTAL#:=[TOTAL COST])
```

```
RULE NUMBER: 278
IF:
        [TYPE]=0
  and   [FIN_AVAIL]>=[TOTAL COST]
  and   The more detailed costing process has calculated that you
can afford
        approximately [[AREA_AFF_SYS]] m2 of the [[RT_NAAM]] roof
type.
        Is this acceptable? Yes

THEN:
        FRAME("SY_COSTS", #RS#=[RS_NO_ACC], $FINAL$:="Yes")
  and   FRAME("SY_COSTS", #RS#=[RS_NO_ACC], #TOTAL#:=[TOTAL COST])
-----------------------------------------
RULE NUMBER: 279
IF:
        [INFO_DATA]=3
  and   Info frame has been displayed
  and   [SLOT]>0
  and   [INFO_NAME]<>""
  and   [INFO_ADDRESS]<>""
  and   [INFO_TEL]>=0
  and   The material is purchaseable
  and   [INFO_SALE]>=0

THEN:
        FRAME("MAT[[MAT_INFO]].INF", #NO#=[SLOT], $NAME OF
        SUPPLIER$:=[INFO_NAME])
  and   FRAME("MAT[[MAT_INFO]].INF", #NO#=[SLOT], $ADDRESS / VENUE
OF
        SUPPLY$:=[INFO_ADDRESS])
  and     FRAME("MAT[[MAT_INFO]].INF",   #NO#=[SLOT],   #CONTACT
NUMBER#:=[INFO_TEL])

  and     FRAME("MAT[[MAT_INFO]].INF",   #NO#=[SLOT],   #SELLING
PRICE#:=[INFO_SALE])

  and   FRAME("SUPPLIER", #NO#=[[MAT_INFO]], #MAT_SUP#:=1)
-----------------------------------------
RULE NUMBER: 280
IF:
        [INFO_DATA]=3
  and   Info frame has been displayed
  and   [SLOT]>0
  and   [INFO_NAME]<>""
  and   [INFO_ADDRESS]<>""
  and   [INFO_TEL]>=0
  and   The material is freely available

THEN:
        FRAME("MAT[[MAT_INFO]].INF", #NO#=[SLOT], $NAME OF
        SUPPLIER$:=[INFO_NAME])
  and   FRAME("MAT[[MAT_INFO]].INF", #NO#=[SLOT], $ADDRESS / VENUE
OF
        SUPPLY$:=[INFO_ADDRESS])
  and     FRAME("MAT[[MAT_INFO]].INF",   #NO#=[SLOT],   #CONTACT
NUMBER#:=[INFO_TEL])

  and     FRAME("MAT[[MAT_INFO]].INF",   #NO#=[SLOT],   #FREELY
AVAILABLE#:="Yes")
  and   FRAME("SUPPLIER", #NO#=[[MAT_INFO]], #MAT_SUP#:=1)
-----------------------------------------
```

```
RULE NUMBER: 281
IF:
        [INFO_DATA]=1
  and   Info frame has been displayed
  and   [SLOT]>0
  and   [INFO_NAME]<>""
  and   [INFO_ADDRESS]<>""
  and   [INFO_TEL]>=0
  and   [INFO_SALE]>0

THEN:
        FRAME("MOD[[MOD_INFO]].INF", #NO#=[SLOT], $NAME OF
        SUPPLIER$:=[INFO_NAME])
  and   FRAME("MOD[[MOD_INFO]].INF", #NO#=[SLOT], $ADDRESS OF
        SUPPLIER$:=[INFO_ADDRESS])
  and     FRAME("MOD[[MOD_INFO]].INF",   #NO#=[SLOT],   #CONTACT
NUMBER#:=[INFO_TEL])

  and     FRAME("MOD[[MOD_INFO]].INF",   #NO#=[SLOT],   #SELLING
PRICE#:=[INFO_SALE])

  and   FRAME("SUPPLIER", #NO#=[[MOD_INFO_MORE]], #MOD_SUP#:=1)
----------------------------------------
RULE NUMBER: 282
IF:
        [INFO_DATA]=4
  and   Info frame has been displayed
  and   [SLOT]>0
  and   [INFO_NAME]<>""
  and   [INFO_ADDRESS]<>""
  and   [INFO_TEL]>=0
  and   Is the tool for rent OR both
  and   Is the tool rentable per hour OR both
  and   [INFO_RENT_H]>=0

THEN:
        FRAME("TOOL[[TOOL_INFO]].INF", #NO#=[SLOT], $NAME OF
        SUPPLIER$:=[INFO_NAME])
  and   FRAME("TOOL[[TOOL_INFO]].INF", #NO#=[SLOT], $ADDRESS OF
        SUPPLIER$:=[INFO_ADDRESS])
  and   FRAME("TOOL[[TOOL_INFO]].INF", #NO#=[SLOT], #CONTACT
        NUMBER#:=[INFO_TEL])
  and         FRAME("TOOL[[TOOL_INFO]].INF",     #NO#=[SLOT],
#HOURLY#:=[INFO_RENT_H])
  and   FRAME("SUPPLIER", #NO#=[[TOOL_INFO]], #TL_SUP#:=1)
----------------------------------------
RULE NUMBER: 283
IF:
        [INFO_DATA]=4
  and   Info frame has been displayed
  and   [SLOT]>0
  and   [INFO_NAME]<>""
  and   [INFO_ADDRESS]<>""
  and   [INFO_TEL]>=0
  and   Is the tool for rent OR both
  and   Is the tool rentable per day OR both
  and   [INFO_RENT_D]>=0

THEN:
        FRAME("TOOL[[TOOL_INFO]].INF", #NO#=[SLOT], $NAME OF
        SUPPLIER$:=[INFO_NAME])
  and   FRAME("TOOL[[TOOL_INFO]].INF", #NO#=[SLOT], $ADDRESS OF
        SUPPLIER$:=[INFO_ADDRESS])
  and   FRAME("TOOL[[TOOL_INFO]].INF", #NO#=[SLOT], #CONTACT
        NUMBER#:=[INFO_TEL])
  and         FRAME("TOOL[[TOOL_INFO]].INF",     #NO#=[SLOT],
```

```
#DAILY#:=[INFO_RENT_D])
  and  FRAME("SUPPLIER", #NO#=[[TOOL_INFO]], #TL_SUP#:=1)
-----------------------------------------
RULE NUMBER: 284
IF:
        [INFO_DATA]=4
  and   Info frame has been displayed
  and   [SLOT]>0
  and   [INFO_NAME]<>""
  and   [INFO_ADDRESS]<>""
  and   [INFO_TEL]>=0
  and   Is the tool for sale OR both
  and   [INFO_SALE]>=0

THEN:
        FRAME("TOOL[[TOOL_INFO]].INF", #NO#=[SLOT], $NAME OF
        SUPPLIER$ =[INFO_NAME])
  and   FRAME("TOOL[[TOOL_INFO]].INF", #NO#=[SLOT], $ADDRESS OF
        SUPPLIER$:=[INFO_ADDRESS])
  and   FRAME("TOOL[[TOOL_INFO]].INF", #NO#=[SLOT], #CONTACT
        NUMBER#:=[INFO_TEL])
  and   FRAME("TOOL[[TOOL_INFO]].INF", #NO#=[SLOT], #SELLING
        PRICE#:=[INFO_SALE])
  and   FRAME("SUPPLIER", #NO#=[[TOOL_INFO]], #TL_SUP#:=1)
-------------------------- ------------
RULE NUMBER: 285
IF:
        [INFO_DATA]=2
  and   Info frame has been displayed
  and   [SLOT]>0
  and   [INFO_NAME]<>""
  and   [INFO_ADDRESS]<>""
  and   [INFO_TEL]>=0
  and   Is the equipment for rent OR both
  and   Is the equipment rentable per hour OR both
  and   [INFO_RENT_H]>=0

THEN:
        FRAME("EQUIP[[EQUIP_INFO]].INF", #NO#=[SLOT], $NAME OF
        SUPPLIER$:=[INFO_NAME])
  and   FRAME("EQUIP[[EQUIP_INFO]].INF", #NO#=[SLOT], $ADDRESS OF
        SUPPLIER$:=[INFO_ADDRESS])
  and   FRAME("EQUIP[[EQUIP_INFO]].INF", #NO#=[SLOT], #CONTACT
        NUMBER#:=[INFO_TEL])
  and         FRAME("EQUIP[[EQUIP_INFO]].INF",     #NO#=[SLOT],
#HOURLY#:=[INFO_RENT_H])
  and   FRAME("SUPPLIER", #NO#=[[EQUIP_INFO]], #EQU_SUP#:=1)
-----------------------------------------
RULE NUMBER: 286
IF:
        [INFO_DATA]=2
  and   Info frame has been displayed
  and   [SLOT]>0
  and   [INFO_NAME]<>""
  and   [INFO_ADDRESS]<>""
  and   [INFO_TEL]>=0
  and   Is the equipment for rent OR both
  and   Is the equipment rentable per day OR both
  and   [INFO_RENT_D]>=0

THEN:
        FRAME("EQUIP[[EQUIP_INFO]].INF", #NO#=[SLOT], $NAME OF
        SUPPLIER$:=[INFO_NAME])
  and   FRAME("EQUIP[[EQUIP_INFO]].INF", #NO#=[SLOT], $ADDRESS OF
        SUPPLIER$:=[INFO_ADDRESS])
  and   FRAME("EQUIP[[EQUIP_INFO]].INF", #NO#=[SLOT], #CONTACT
```

```
        NUMBER#:=[INFO_TEL])
  and         FRAME("EQUIP[[EQUIP_INFO]].INF",     #NO#=[SLOT],
#DAILY#:=[INFO_RENT_D])
  and  FRAME("SUPPLIER", #NO#=[[EQUIP_INFO]], #EQU_SUP#:=1)
-----------------------------------------
RULE NUMBER: 287
IF:
        [INFO_DATA]=2
  and  Info frame has been displayed
  and  [SLOT]>0
  and  [INFO_NAME]<>""
  and  [INFO_ADDRESS]<>""
  and  [INFO_TEL]>=0
  and  Is the equipment for sale OR both
  and  [INFO_SALE]>=0

THEN:
        FRAME("EQUIP[[EQUIP_INFO]].INF", #NO#=[SLOT], $NAME OF
        SUPPLIER$:=[INFO_NAME])
  and FRAME("EQUIP[[EQUIP_INFO]].INF", #NO#=[SLOT], $ADDRESS OF
        SUPPLIER$:=[INFO_ADDRESS])
  and  FRAME("EQUIP[[EQUIP_INFO]].INF", #NO#=[SLOT], #CONTACT
        NUMBER#:=[INFO_TEL])
  and  FRAME("EQUIP[[EQUIP_INFO]].INF", #NO#=[SLOT], #SELLING
        PRICE#:=[INFO_SALE])
  and  FRAME("SUPPLIER", #NO#=[[EQUIP_INFO]], #EQU_SUP#:=1)
-----------------------------------------
RULE NUMBER: 288
IF:
        [INFO_DATA]=2
  and  Info frame has been displayed
  and  [SLOT]>0
  and  [INFO_NAME]<>""
  and  [INFO_ADDRESS]<>""
  and  [INFO_TEL]>=0
  and  Is the equipment for sale OR both
  and  [INFO_SALE]>=0

THEN:
        FRAME("EQUIP[[EQUIP_INFO]].INF", #NO#=[SLOT], $NAME OF
        SUPPLIER$:=[INFO_NAME])
  and FRAME("EQUIP[[EQUIP_INFO]].INF", #NO#=[SLOT], $ADDRESS OF
        SUPPLIER$:=[INFO_ADDRESS])
  and  FRAME("EQUIP[[EQUIP_INFO]].INF", #NO#=[SLOT], #CONTACT
        NUMBER#:=[INFO_TEL])
  and  FRAME("EQUIP[[EQUIP_INFO]].INF", #NO#=[SLOT], #SELLING
        PRICE#:=[INFO_SALE])
  and  FRAME("SUPPLIER", #NO#=[[EQUIP_INFO]], #EQU_SUP#:=1)
-----------------------------------------
RULE NUMBER: 289
IF:
        [INFO_DATA]=5
  and  Info frame has been displayed
  and  [SLOT]>0
  and  [INFO_NAME]<>""
  and  [INFO_ADDRESS]<>""
  and  [INFO_TEL]>=0
  and  Does the labour charge per day OR both
  and  [INFO_RENT_D]>=0

THEN:
        FRAME("LAB[[LAB_INFO]].INF", #NO#=[SLOT], $PERSON /
        COMPANY$:=[INFO_NAME])
  and    FRAME("LAB[[LAB_INFO]].INF",  #NO#=[SLOT],  $ADDRESS  OF
PERSON /
        COMPANY$:=[INFO_ADDRESS])
```

```
  and     FRAME("LAB[[LAB_INFO]].INF",   #NO#=[SLOT],   #CONTACT
NUMBER#:=[INFO_TEL])

  and        FRAME("LAB[[LAB_INFO]].INF",    #NO#=[SLOT],
#DAILY#:=[INFO_RENT_D])
  and  FRAME("SUPPLIER", #NO#=[[LAB_INFO]], #LAB_SUP#:=1)
----------------------------------------
RULE NUMBER: 290
IF:
       [INFO_DATA]=5
  and  Info frame has been displayed
  and  [SLOT]>0
  and  [INFO_NAME]<>""
  and  [INFO_ADDRESS]<>""
  and  [INFO_TEL]>=0
  and  Does the labour charge per hour OR both
  and  [INFO_RENT_H]>=0

THEN:
       FRAME("LAB[[LAB_INFO]].INF", #NO#=[SLOT], $PERSON /
       COMPANY$:=[INFO_NAME])
  and   FRAME("LAB[[LAB_INFO]].INF", #NO#=[SLOT], $ADDRESS OF
PERSON /
       COMPANY$:=[INFO_ADDRESS])
  and     FRAME("LAB[[LAB_INFO]].INF",   #NO#=[SLOT],   #CONTACT
NUMBER#:=[INFO_TEL])

  and        FRAME("LAB[[LAB_INFO]].INF",    #NO#=[SLOT],
#HOURLY#:=[INFO_RENT_H])
  and  FRAME("SUPPLIER", #NO#=[[LAB_INFO]], #LAB_SUP#:=1)
----------------------------------------
RULE NUMBER: 291
IF:
       [INFO_DATA]=1
  and  [RSNO1]<>"X"
  and  [RSNO2]<>"X"
  and  [RSNO3]<>"X"
  and  [RSNO4]<>"X"
  and  [RSNO5]<>"X"
  and  [RSNO6]<>"X"
  and  [RSNO7]<>"X"
  and  [RSNO8]<>"X"
  and  [RSNO9]<>"X"
  and  [RSNO10]<>"X"
  and  [MOD_INFO_MORE]>0
  and  [MD1]<>"x"
  and  [MD2]<>"x"
  and  [MD3]<>"x"
  and  [MD4]<>"x"
  and  [MD5]<>"x"
  and  [MD6]<>"x"
  and  [MD7]<>"x"
  and  [MD8]<>"x"
  and  [MD9]<>"x"
  and  [MD10]<>"x"
  and  [MD11]<>"x"
  and  [MD12]<>"x"
  and  [MD13]<>"x"
  and  [MD14]<>"x"
  and  [MD15]<>"x"
  and  [MD16]<>"x"
  and  [MD17]<>"x"
  and  [MD18]<>"x"
  and  [MD19]<>"x"
  and  [MD20]<>"x"
  and  [MOD_INFO]>0
```

```
THEN:
        DISPLAY(MOD[[MOD_INFO]].INF)
  and   DISPLAY(SLOT.INF)
  and   Info frame has been displayed
----------------------------------------
RULE NUMBER: 292
IF:
        [INFO_DATA]=2
  and   [EQ1]<>"x"
  and   [EQ2]<>"x"
  and   [EQ3]<>"x"
  and   [EQ4]<>"x"
  and   [EQ5]<>"x"
  and   [EQ6]<>"x"
  and   [EQ7]<>"x"
  and   [EQUIP_INFO]>0

THEN:
        DISPLAY(EQUIP[[EQUIP_INFO]].INF)
  and   DISPLAY(SLOT.INF)
  and   Info frame has been displayed
----------------------------------------
RULE NUMBER: 293
IF:
        [INFO_DATA]=3
  and   [MT1]<>"x"
  and   [MT2]<>"x"
  and   [MT3]<>"x"
  and   [MT4]<>"x"
  and   [MT5]<>"x"
  and   [MT6]<>"x"
  and   [MT7]<>"x"
  and   [MT8]<>"x"
  and   [MT9]<>"x"
  and   [MT10]<>"x"
  and   [MT11]<>"x"
  and   [MT12]<>"x"
  and   [MT13]<>"x"
  and   [MT14]<>"x"
  and   [MT15]<>"x"
  and   [MAT_INFO]>0

THEN:
        DISPLAY(MAT[[MAT_INFO]].INF)
  and   DISPLAY(SLOT.INF)
  and   Info frame has been displayed
----------------------------------------
RULE NUMBER: 294
IF:
        [INFO_DATA]=4
  and   [TL1]<>"x"
  and   [TL2]<>"x"
  and   [TL3]<>"x"
  and   [TL4]<>"x"
  and   [TL5]<>"x"
  and   [TL6]<>"x"
  and   [TL7]<>"x"
  and   [TL8]<>"x"
  and   [TL9]<>"x"
  and   [TL10]<>"x"
  and   [TOOL_INFO]>0

THEN:
        DISPLAY(TOOL[[TOOL_INFO]].INF)
  and   DISPLAY(SLOT.INF)
  and   Info frame has been displayed
```

```
RULE NUMBER: 295
IF:
        [INFO_DATA]=5
  and   [LB1]<>"x"
  and   [LB2]<>"x"
  and   [LB3]<>"x"
  and   [LB4]<>"x"
  and   [LB5]<>"x"
  and   [LB6]<>"x"
  and   [LB7]<>"x"
  and   [LB8]<>"x"
  and   [LAB_INFO]>0

THEN:
        DISPLAY(LAB[[LAB_INFO]].INF)
  and   DISPLAY(SLOT.INF)
  and   Info frame has been displayed
-----------------------------------------
RULE NUMBER: 296
IF:
        Closest or exact area in which town/city falls is
Transvaal
  and   [TVL]>0

THEN:
         FRAME("CLIMATE2",    $DATA$="Province/Homeland",
$VALUE$:="Transvaal")
  and   FRAME("CLIMATE2", $DATA$="City/Town", $VALUE$:=[TOWN_TVL])

  and   FRAME("CLIMATE2", $DATA$="Region", $VALUE$:=[REGION_TVL])
  and    FRAME("NUMBERS.FRM", $ITEM$="Clim_chg", #NUM#:=1)
  and   Climate can proceed
-----------------------------------------
RULE NUMBER: 297
IF:
        Closest or exact area in which town/city falls is Orange
Free State
  and   [OFS]>0

THEN:
         FRAME("CLIMATE2",    $DATA$="Province/Homeland",
$VALUE$:="Orange Free
        State")
  and   FRAME("CLIMATE2", $DATA$="City/Town", $VALUE$:=[TOWN_OFS])

  and   FRAME("CLIMATE2", $DATA$="Region", $VALUE$:=[REGION_OFS])
  and    FRAME("NUMBERS.FRM", $ITEM$="Clim_chg", #NUM#:=1)
  and   Climate can proceed
-----------------------------------------
RULE NUMBER: 298
IF:
        Closest or exact area in which town/city falls is Natal
  and   [NAT]>0

THEN:
         FRAME("CLIMATE2",    $DATA$="Province/Homeland",
$VALUE$:="Natal")
  and   FRAME("CLIMATE2", $DATA$="City/Town", $VALUE$:=[TOWN_NAT])

  and   FRAME("CLIMATE2", $DATA$="Region", $VALUE$:=[REGION_NAT])
  and    FRAME("NUMBERS.FRM", $ITEM$="Clim_chg", #NUM#:=1)
  and   Climate can proceed
-----------------------------------------
RULE NUMBER: 299
IF:
        Closest or exact area in which town/city falls is Cape
```

```
Province
  and  [CP]>0

THEN:
        FRAME("CLIMATE2",    $DATA$="Province/Homeland",
$VALUE$:="Cape Province")

  and FRAME("CLIMATE2", $DATA$="City/Town", $VALUE$:=[TOWN_CP])
  and FRAME("CLIMATE2", $DATA$="Region", $VALUE$:=[REGION_CP])
  and  FRAME("NUMBERS.FRM", $ITEM$="Clim_chg", #NUM#:=1)
  and  Climate ca  proceed
-----------------------------------------
RULE NUMBER: 300
IF:
      Closest or exact area in which town/city falls is
Swaziland
  and  [SWAZ]>0

THEN:
        FRAME("CLIMATE2",    $DATA$="Province/Homeland",
$VALUE$:="Swaziland")
  and       FRAME("CLIMATE2",    $DATA$="City/Town",
$VALUE$:=[TOWN_SWAZ])
  and FRAME("CLIMATE2", $DATA$="Region", $VALUE$:=[REGION_SWAZ])

  and  FRAME("NUMBERS.FRM", $ITEM$="Clim_chg", #NUM#:=1)
  and  Climate can proceed
-----------------------------------------
RULE NUMBER: 301
IF:
      Closest or exact area in which town/city falls is Venda
  and  [VEN]>0

THEN:
        FRAME("CLIMATE2",    $DATA$="Province/Homeland",
$VALUE$:="Venda")
  and FRAME("CLIMATE2", $DATA$="City/Town", $VALUE$:=[TOWN_VEN])

  and FRAME("CLIMATE2", $DATA$="Region", $VALUE$:=[REGION_VEN])
  and  FRAME("NUMBERS.FRM", $ITEM$="Clim_chg", #NUM#:=1)
  and  Climate can proceed
-----------------------------------------
RULE NUMBER: 302
IF:
      Closest or exact area in which town/city falls is Bop
  and  [BOP]>0

THEN:
        FRAME("CLIMATE2",    $DATA$="Province/Homeland",
$VALUE$:="Boppp")
  and FRAME("CLIMATE2", $DATA$="City/Town", $VALUE$:=[TOWN_BOP])

  and FRAME("CLIMATE2", $DATA$="Region", $VALUE$:=[REGION_BOP])
  and  FRAME("NUMBERS.FRM", $ITEM$="Clim_chg", #NUM#:=1)
  and  Climate can proceed
-----------------------------------------
RULE NUMBER: 303
IF:
      Closest or exact area in which town/city falls is Transkei
  and  [TRK]>0

THEN:
        FRAME("CLIMATE2",    $DATA$="Province/Homeland",
$VALUE$:="Transkei")
  and FRAME("CLIMATE2", $DATA$="City/Town", $VALUE$:=[TOWN_TRK])
```

```
  and FRAME("CLIMATE2", $DATA$="Region", $VALUE$:=[REGION_TRK])
  and  FRAME("NUMBERS.FRM", $ITEM$="Clim_chg", #NUM#:=1)
  and  Climate can proceed
----------------------------------------
RULE NUMBER: 304
IF:
       Climate can proceed

THEN:
       FRAME("CLIMATE2", #No#=[NUM], $Value$:=[CLIM_SUIT])
----------------------------------------
RULE NUMBER: 305
IF:
       [SYS_PURCH_COST]>0
  and  [SYS_SELF_COST]>0
  and  [SYS_AREA]>0

THEN:
       [AREA_AFF] IS GIVEN THE VALUE
[FIN_AVAIL]/((                    ]+[SYS_SELF_COST])/2)*[SYS_AREA]
----------------------------------------
RULE NUMBER: 306
IF:
       [TYPE_FACTOR]="Unit"

THEN:
       The roofing type for which you wish to enter cost factors,
is a unit
----------------------------------------
RULE NUMBER: 307
IF:
       [TYPE_FACTOR]="Sys"

THEN:
       The roofing type for which you wish to enter cost factors,
is a system
----------------------------------------
RULE NUMBER: 308
IF:
       The roofing type for which you wish to enter cost factors,
is a unit
  and  How did you categorise yourself when you ran buildroof?
Self-builder

THEN:
       [CAT_FACTOR] IS GIVEN THE VALUE "SELF"
----------------------------------------
RULE NUMBER: 309
IF:
       The roofing type for which you wish to enter cost factors,
is a unit
  and  How did you categorise yourself when you ran buildroof?
Artisan

THEN:
       [CAT_FACTOR] IS GIVEN THE VALUE "ART"
----------------------------------------
RULE NUMBER: 310
IF:
       The roofing type for which you wish to enter cost factors,
is a unit
  and  How did you categorise yourself when you ran buildroof?
Small scale
       contractor

THEN:
```

[CAT_FACTOR] IS GIVEN THE /ALUE "CONT"

RULE NUMBER: 311
IF:
The roofing type for which you wish to enter cost factors, is a system
and Did you build or purchase your [[NAME_FACTOR]] modules? Build yourself

THEN:
[CAT_FACTOR] IS GIVEN THE VALUE "SELF"

RULE NUMBER: 312
IF:
The roofing type for which you wish to enter cost factors, is a system
and Did you build or purchase your [[NAME_FACTOR]] modules? Purchase

THEN:
[CAT_FACTOR] IS GIVEN THE VALUE "PURCH"

RULE NUMBER: 313
IF:
([SU_ST_FACTOR]+1)>[SU_FI_FACTOR]

THEN:
[SUNO2] IS GIVEN THE VALUE ""

RULE NUMBER: 314
IF:
([SU_ST_FACTOR]+2)>[SU_FI_FACTOR]

THEN:
[SUNO3] IS GIVEN THE VALUE ""

RULE NUMBER: 315
IF:
([SU_ST_FACTOR]+3)>[SU_FI_FACTOR]

THEN:
[SUNO4] IS GIVEN THE VALUE ""

RULE NUMBER: 316
IF:
([SU_ST_FACTOR]+4)>[SU_FI_FACTOR]

THEN:
[SUNO5] IS GIVEN THE VALUE ""

RULE NUMBER: 317
IF:
([SU_ST_FACTOR]+5)>[SU_FI_FACTOR]

THEN:
[SUNO6] IS GIVEN THE VALUE ""

RULE NUMBER: 318
IF:
([SU_ST_FACTOR]+6)>[SU_FI_FACTOR]

THEN:
[SUNO7] IS GIVEN THE VALUE ""

```
RULE NUMBER: 319
IF:
        ([SU_ST_FACTOR]+7)>[SU_FI_FACTOR]

THEN:
        [SUNO8] IS GIVEN THE VALUE ""
-----------------------------------------
RULE NUMBER: 320
IF:
        ([SU_ST_FACTOR]+8)>[SU_FI_FACTOR]

THEN:
        [SUNO9] IS GIVEN THE VALUE ""
-----------------------------------------
RULE NUMBER: 321
IF:
        ([SU_ST_FACTOR]+9)>[SU_FI_FACTOR]

THEN:
        [SUNO10] IS GIVEN THE VALUE ""
-----------------------------------------
RULE NUMBER: 322
IF:
        ([SU_ST_FACTOR]+10)>[SU_FI_FACTOR]

THEN:
        [SUNO11] IS GIVEN THE VALUE ""
-----------------------------------------
RULE NUMBER: 323
IF:
        ([SU_ST_FACTOR]+11)>[SU_FI_FACTOR]

THEN:
        [SUNO12] IS GIVEN THE VALUE ""
-----------------------------------------
RULE NUMBER: 324
IF:
        ([SU_ST_FACTOR]+12)>[SU_FI_FACTOR]

THEN:
        [SUNO13] IS GIVEN THE VALUE ""
-----------------------------------------
RULE NUMBER: 325
IF:
        ([SU_ST_FACTOR]+13)>[SU_FI_FACTOR]

THEN:
        [SUNO14] IS GIVEN THE VALUE ""
-----------------------------------------
RULE NUMBER: 326
IF:
        ([SU_ST_FACTOR]+14)>[SU_FI_FACTOR]

THEN:
        [SUNO15] IS GIVEN THE VALUE ""
-----------------------------------------
RULE NUMBER: 327
IF:
        The roofing type for which you wish to enter cost factors,
is a system
  and   [OLD_CASES]=0

THEN:
        [MONTHS3] IS GIVEN THE VALUE [MONTHS2]-[MONTHS1]
  and   [NEW_CASES] IS GIVEN THE VALUE ([OLD_CASES]+1)
  and   FRAME("COST_FAC", #RS#=[RS_TO_COST],
```

```
        #CASES.[[CAT_FACTOR]]#:=[NEW_CASES])
   and          [MOD_FAC]    IS    GIVEN    THE    VALUE
[ACTUAL_MODCOST]*(1-([MONTHS3]*[IR]/1200))
  and  [MOD_FAC] IS GIVEN THE VALUE ([MOD_FAC]/[PRED_MODCOST])
   and          FRAME("COST_FAC",    #RS#=[RS_TO_COST],
#[[CAT_FACTOR]].MOD#:=[MOD_FAC])
  and  [EQUIP_FAC] IS GIVEN THE VALUE
       [ACTUAL_EQUIPCOST]*(1-([MONTHS3]*[IR]/1200))
   and          [EQUIP_FAC]    IS    GIVEN    THE    VALUE
[EQUIP_FAC]/[PRED_EQUIPCOST]
  and  FRAME("COST_FAC", #RS#=[RS_TO_COST],
       #[[CAT_FACTOR]].EQUIP#:=[EQUIP_FAC])
   and          [MAT_FAC]    IS    GIVEN    THE    VALUE
[ACTUAL_MATCOST]*(1-([MONTHS3]*[IR]/1200))
  and  [MAT_FAC] IS GIVEN THE VALUE ([MAT_FAC]/[PRED_MATCOST])
   and          FRAME("COST_FAC",    #RS#=[RS_TO_COST],
#[[CAT_FACTOR]].MATS#:=[MAT_FAC])
  and  [TOOL_FAC] IS GIVEN THE VALUE
       [ACTUAL_TOOLCOST]*(1-([MONTHS3]*[IR]/1200))
  and  [TOOL_FAC] IS GIVEN THE VALUE [TOOL_FAC]/[PRED_TOOLCOST]
  and  FRAME("COST_FAC", #RS#=[RS_TO_COST],
       #[[CAT_FACTOR]].TOOLS#:=[TOOL_FAC])
   and          [LAB_FAC]    IS    GIVEN    THE    VALUE
[ACTUAL_LABCOST]*(1-([MONTHS3]*[IR]/1200))
  and  [LAB_FAC] IS GIVEN THE VALUE [LAB_FAC]/[PRED_LABCOST]
   and          FRAME("COST_FAC",    #RS#=[RS_TO_COST],
#[[CAT_FACTOR]].LAB#:=[LAB_FAC])
  and  [ACTUAL_TOTCOST] IS GIVEN THE VALUE

[ACTUAL_MODCOST]+[ACTUAL_EQUIPCOST]+[ACTUAL_MATCOST]+[ACTUAL_TOOL
       COST]+[ACTUAL_LABCOST]
  and  [INFL_TOTCOST] IS GIVEN THE VALUE
       ([ACTUAL_TOTCOST]*(1+([MONTHS1]*[IR]/1200))/[AREA_FACTOR])
  and  [INFL_TOTCOST] IS GIVEN THE VALUE
       (([INFL_TOTCOST]*[SIZE_FACTOR])+([INITIAL_TOTCOSTS]))/2
  and  FRAME("SYSTEMS", #RS#=[RS_TO_COST],
       #COST.[[CAT_FACTOR]]#:=[INFL_TOTCOST])
-----------------------------------------
RULE NUMBER: 328
IF:
       The roofing type for which you wish to enter cost factors,
is a system
  and  [OLD_CASES]>0

THEN:
       [MONTHS3] IS GIVEN THE VALUE [MONTHS2]-[MONTHS1]
  and  [NEW_CASES] IS GIVEN THE VALUE ([OLD_CASES]+1)
  and  FRAME("COST_FAC", #RS#=[RS_TO_COST],
       #CASES.[[CAT_FACTOR]]#:=[NEW_CASES])
   and          [MOD_FAC]    IS    GIVEN    THE    VALUE
[ACTUAL_MODCOST]*(1-([MONTHS3]*[IR]/1200))
  and  [MOD_FAC] IS GIVEN THE VALUE

(([MOD_FAC]/[PRED_MODCOST]*[EU_MODFAC])+(5*[OLD_MODFAC]))/6
   and          FRAME("COST_FAC",    #RS#=[RS_TO_COST],
#[[CAT_FACTOR]].MOD#:=[MOD_FAC])
  and  [EQUIP_FAC] IS GIVEN THE VALUE
       [ACTUAL_EQUIPCOST]*(1-([MONTHS3]*[IR]/1200))
  and  [EQUIP_FAC] IS GIVEN THE VALUE

(([EQUIP_FAC]/[PRED_EQUIPCOST]*[EU_EQUIPFAC])+(5*[OLD_EQUIPFAC]))
       /6
  and  FRAME("COST_FAC", #RS#=[RS_TO_COST],
       #[[CAT_FACTOR]].EQUIP#:=[EQUIP_FAC])
   and          [MAT_FAC]    IS    GIVEN    THE    VALUE
[ACTUAL_MATCOST]*(1-([MONTHS3]*[IR]/1200))
```

```
  and   [MAT_FAC] IS GIVEN THE VALUE

(([MAT_FAC]/[PRED_MATCOST]*[EU_MATFAC])+(5*[OLD_MATFAC]))/6
   and        FRAME("COST_FAC",    #RS#=[RS_TO_COST],
#[[CAT_FACTOR]].MATS#:=[MAT_FAC])
  and   [TOOL_FAC] IS GIVEN THE VALUE
        [ACTUAL_TOOLCOST]*(1-([MONTHS3]*[IR]/1200))
  and   [TOOL_FAC] IS GIVEN THE VALUE

(([TOOL_FAC]/[PRED_TOOLCOST]*[EU_TOOLFAC])+(5*[OLD_TOOLFAC]))/6
  and   FRAME("COST_FAC", #RS#=[RS_TO_COST],
        #[[CAT_FACTOR]].TOOLS#:=[TOOL_FAC])
   and        [LAB_FAC]    IS    GIVEN    THE    VALUE
[ACTUAL_LABCOST]*(1-([MONTHS3]*[IR]/1200))
  and   [LAB_FAC] IS GIVEN THE VALUE

(([LAB_FAC]/[PRED_LABCOST]*[EU_LABFAC])+(5*[OLD_LABFAC]))/6
   and        FRAME("COST_FAC",    #RS#=[RS_TO_COST],
#[[CAT_FACTOR]].LAB#:=[LAB_FAC])
  and   [ACTUAL_TOTCOST] IS GIVEN THE VALUE

[ACTUAL_MODCOST]+[ACTUAL_EQUIPCOST]+[ACTUAL_MATCOST]+[ACTUAL_TOOL
        COST]+[ACTUAL_LABCOST]
  and   [INFL_TOTCOST] IS GIVEN THE VALUE
        ([ACTUAL_TOTCOST]*(1+([MONTHS1]*[IR]/1200))/[AREA_FACTOR])
        [INFL_TOTCOST] IS GIVEN THE VALUE
          [INFL_TOTCOST]*[SIZE_FACTOR])+(5*[INITIAL_TOTCOSTS]))/6
          ("SYSTEMS", #RS#=[RS_TO_COST],
            [CAT_FACTOR]]#:=[INFL_TOTCOST])
-------------------------------
RULE NUMBER:  29    (285)
IF:
        The routing type for which you wish to enter cost factors,
is a unit
  and   [OLD_CASES]=0
  and   [SUBUNIT_FACTOR]>0

THEN:
        [MONTHS3] IS GIVEN THE VALUE [MONTHS2]-[MONTHS1]
  and   [NEW_CASES] IS GIVEN THE VALUE ([OLD_CASES]+1)
  and   FRAME("COST_FAC", #RS#=[RS_TO_COST],
        #CASES.[[CAT_FACTOR]]#:=[NEW_CASES])
   and        [MOD_FAC]    IS    GIVEN    THE    VALUE
[ACTUAL_MODCOST]*(1-([MONTHS3]*[IR]/1200))
  and   [MOD_FAC] IS GIVEN THE VALUE ([MOD_FAC]/[PRED_MODCOST])
   and        FRAME("COST_FAC",    #RS#=[RS_TO_COST],
#[[CAT_FACTOR]].MOD#:=[MOD_FAC])
  and   [EQUIP_FAC] IS GIVEN THE VALUE
        [ACTUAL_EQUIPCOST]*(1-([MONTHS3]*[IR]/1200))
   and        [EQUIP_FAC]    IS    GIVEN    THE    VALUE
[EQUIP_FAC]/[PRED_EQUIPCOST]
  and   FRAME("COST_FAC", #RS#=[RS_TO_COST],
        #[[CAT_FACTOR]].EQUIP#:=[EQUIP_FAC])
   and        [MAT_FAC]    IS    GIVEN    THE    VALUE
[ACTUAL_MATCOST]*(1-([MONTHS3]*[IR]/1200))
  and   [MAT_FAC] IS GIVEN THE VALUE ([MAT_FAC]/[PRED_MATCOST])
   and        FRAME("COST_FAC",    #RS#=[RS_TO_COST],
#[[CAT_FACTOR]].MATS#:=[MAT_FAC])
  and   [TOOL_FAC] IS GIVEN THE VALUE
        [ACTUAL_TOOLCOST]*(1-([MONTHS3]*[IR]/1200))
  and   [TOOL_FAC] IS GIVEN THE VALUE [TOOL_FAC]/[PRED_TOOLCOST]
  and   FRAME("COST_FAC", #RS#=[RS_TO_COST],
        #[[CAT_FACTOR]].TOOLS#:=[TOOL_FAC])
   and        [LAB_FAC]    IS    GIVEN    THE    VALUE
[ACTUAL_LABCOST]*(1-([MONTHS3]*[IR]/1200))
  and   [LAB_FAC] IS GIVEN THE VALUE [LAB_FAC]/[PRED_LABCOST]
```

```
  and       FRAME("COST_FAC",    #RS#=[RS_TO_COST],
#[[CAT_FACTOR]].LAB#:=[LAB_FAC])
  and  [ACTUAL_TOTCOST] IS GIVEN THE VALUE

[ACTUAL_MODCOST]+[ACTUAL_EQUIPCOST]+[ACTUAL_MATCOST]+[ACTUAL_TOOL
      COST]+[ACTUAL_LABCOST]
  and  [INFL_TOTCOST] IS GIVEN THE VALUE
       ([ACTUAL_TOTCOST]*(1+([MONTHS1]*[IR]/1200)))
  and  [SU_COST_FACTOR_SLOT] IS GIVEN THE VALUE
       ([SUBUNIT_FACTOR]+[SU_ST_FACTOR]-1)
  and  [INFL_TOTCOST] IS GIVEN THE VALUE
       (([INFL_TOTCOST])+([INITIAL_TOTCOST]))/2
  and  FRAME("UNITS", #NO#=[SU_COST_FACTOR_SLOT],
       #COST.[[CAT_FACTOR]]#:=[INFL_TOTCOST])
-----------------------------------------
RULE NUMBER: 330
IF:
       The roofing type for which you wish to enter cost factors,
in a unit
  and  [OLD_CASES]>0
  and  [SUBUNIT_FACTOR]>0

THEN:
       [MONTHS3] IS GIVEN THE VALUE [MONTHS2]-[MONTHS1]
  and  [NEW_CASES] IS GIVEN THE VALUE ([OLD_CASES]+1)
  and  FRAME(   ST_FAC", #RS#=[RS_TO_COST],
       #CASES. _[CAT_FACTOR]]#:=[NEW_CASES])
   and        [MOD_FAC]    IS    GIVEN    THE    VALUE
[ACTUAL_MODCOST]*(1-([MONTHS3]*[IR]/1200))
  and  [MOD_FAC] IS GIVEN THE VALUE

(([MOD_FAC]/[PRED_MODCOST]*[EU_MODFAC])+(5*[OLD_MODFAC]))/6
   and       FRAME("COST_FAC",    #RS#=[RS_TO_COST],
#[[CAT_FACTOR]].MOD#:=[MOD_FAC])
  and  [EQUIP_FAC] IS GIVEN THE VALUE
       [ACTUAL_EQUIPCOST]*(1-([MONTHS3]*[IR]/1200))
  and  [EQUIP_FAC] IS GIVEN THE VALUE

(([EQUIP_FAC]/[PRED_EQUIPCOST]*[EU_EQUIPFAC])+(5*[OLD_EQUIPFAC]))
      /6
  and  FRAME("COST_FAC", #RS#=[RS_TO_COST],
       #[[CAT_FACTOR]].EQUIP#:=[EQUIP_FAC])
   and        [MAT_FAC]    IS    GIVEN    THE    VALUE
[ACTUAL_MATCOST]*(1-([MONTHS3]*[IR]/1200))
  and  [MAT_FAC] IS GIVEN THE VALUE

(([MAT_FAC]/[PRED_MATCOST]*[EU_MATFAC])+(5*[OLD_MATFAC]))/6
   and       FRAME("COST_FAC",    #RS#=[RS_TO_COST],
#[[CAT_FACTOR]].MATS#:=[MAT_FAC])
  and  [TOOL_FAC] IS GIVEN THE VALUE
       [ACTUAL_TOOLCOST]*(1-([MONTHS3]*[IR]/1200))
  and  [TOOL_FAC] IS GIVEN THE VALUE

(([TOOL_FAC]/[PRED_TOOLCOST]*[EU_TOOLFAC])+(5*[OLD_TOOLFAC]))/6
  and  FRAME("COST_FAC", #RS#=[RS_TO_COST],
       #[[CAT_FACTOR]].TOOLS#:=[TOOL_FAC])
   and        [LAB_FAC]    IS    GIVEN    THE    VALUE
[ACTUAL_LABCOST]*(1-([MONTHS3]*[IR]/1200))
  and  [LAB_FAC] IS GIVEN THE VALUE

(([LAB_FAC]/[PRED_LABCOST]*[EU_LABFAC])+(5*[OLD_LABFAC]))/6
   and       FRAME("COST_FAC",    #RS#=[RS_TO_COST],
#[[CAT_FACTOR]].LAB#:=[LAB_FAC])
  and  [ACTUAL_TOTCOST] IS GIVEN THE VALUE

[ACTUAL_MODCOST]+[ACTUAL_EQUIPCOST]+[ACTUAL_MATCOST]+[ACTUAL_TOOL
```

```
        COST]+[ACTUAL_LABCOST]
  and   [INFL_TOTCOST] IS GIVEN THE VALUE
        ([ACTUAL_TOTCOST]*(1+([MONTHS1]*[IR]/1200)))
  and   [SU_COST_FACTOR_SLOT] IS GIVEN THE VALUE
        ([SUBUNIT_FACTOR]+[SU_ST_FACTOR]-1)
  and   [INFL_TOTCOST] IS GIVEN THE VALUE
        (([INFL_TOTCOST])+(5*[INITIAL_TOTCOST]))/6
  and   FRAME("UNITS", #NO#=[SU_COST_FACTOR_SLOT],
        #COST.[[CAT_FACTOR]]#:=[INFL_TOTCOST])
----------------------------------------
RULE NUMBER: 331
IF:
        [MIN_TEMP]>[NRS_MIN_TEMP]
  and   [MAX_TEMP]<[NRS_MAX_TEMP]
  and   [MAX_RAIN]<[NRS_MAX_RAIN]

THEN:
         FRAME("CLIMATE1",    #NO#=[NRS_CLIM_COUNTER],
$[[RS_NUM]]$:="Yes")

ELSE:
         FRAME("CLIMATE1",    #NO#=[NRS_CLIM_COUNTER],
$[[RS_NUM]]$:="No")
----------------------------------------
RULE NUMBER: 332
IF:
        Is the [[NRS_NAME]] a unit or a system? ^^Unit^^

THEN:
        [RS_NUM] IS GIVEN THE VALUE ([RS_NUM]+1)
  and        [NRS_UNIT_COUNTER]    IS    GIVEN    THE    VALUE
([NRS_UNIT_COUNTER]+1)
  and   FRAME("ALL", $TYPE$="Total", #NUM#:=[RS_NUM])
  and   FRAME("ALL", $TYPE$="Units", #NUM#:=[NRS_UNIT_COUNTER])
  and   FRAME("EXTRAS.FRM", #RS#=[RS_NUM], $NAME$:=[NRS_NAME])
  and   FRAME("RS", #RS#=[RS_NUM], $NAME$:=[NRS_NAME])
  and   FRAME("RS", #RS#=[RS_NUM], $TYPE$:="Unit")
  and  FRAME("UNIT_INF", #NO#=[NRS_UNIT_COUNTER], #RS#:=[RS_NUM])

  and        FRAME("UNIT_INF",    #NO#=[NRS_UNIT_COUNTER],
#SUB_UNITS#:=[NRS_SU_NO])
  and        FRAME("UNIT_INF",    #NO#=[NRS_UNIT_COUNTER],
#START#:=([LAST_FINISH]+1))
  and   FRAME("UNIT_INF", #NO#=[NRS_UNIT_COUNTER],
        #FINISH#:=([LAST_FINISH]+[NRS_SU_NO]))
  and  FRAME("MD_EUINF", #MD#=[RS_NUM], $RANGE_NOME$:=[NRS_NAME])

  and   FRAME("NUMBERS.FRM", $ITEM$="Modules", #NUM#:=[RS_NUM])
  and   [E] IS GIVEN THE VALUE 1
  and   FRAME("COST_FAC", #RS#=[RS_NUM], $NAME$:=[NRS_NAME])
  and   FRAME("NUMBERS.FRM", $ITEM$="Clim_chg", #NUM#:=1)
  and   FRAME("CLIMATE2", #NO#=[RS_NUM], $NAME$:=[NRS_NAME])
  and  FRAME("SUPPLIER", #NO#=[MOD_NUM], $MOD_NAME$:=[NRS_NAME])
----------------------------------------
RULE NUMBER: 333
IF:
        Is the [[NRS_NAME]] a unit or a system? ^^System^^

THEN:
        [RS_NUM] IS GIVEN THE VALUE ([RS_NUM]+1)
  and   FRAME("ALL", $TYPE$="Total", #NUM#:=[RS_NUM])
  and   FRAME("NUMBERS.FRM", $ITEM$="Modules", #NUM#:=[RS_NUM])
  and        [NRS_SYSTEM_COUNTER]    IS    GIVEN    THE    VALUE
([NRS_SYSTEM_COUNTER]+1)
   and        FRAME("ALL",    $TYPE$="Systems",
#NUM#:=[NRS_SYSTEM_COUNTER])
```

```
  and  FRAME("EXTRAS.FRM", #RS#=[RS_NUM], $NAME$:=[NRS_NAME])
  and  FRAME("RS", #RS#=[RS_NUM], $NAME$:=[NRS_NAME])
  and  FRAME("RS", #RS#=[RS_NUM], $TYPE$:="Sys")
  and        FRAME("SYSTEMS",    #SYS#=[NRS_SYSTEM_COUNTER],
#RS#:=[RS_NUM])
  and        FRAME("SYSTEMS",    #SYS#=[NRS_SYSTEM_COUNTER],
$SYS_NAME$:=[NRS_NAME])
  and  FRAME("SYSTEMS", #SYS#=[NRS_SYSTEM_COUNTER],
       #AREA#:=[NRS_AREA_PER_SYS])
  and  FRAME("SYSTEMS", #SYS#=[NRS_SYSTEM_COUNTER],
       #SELF#:=[NRS_SYS_COST_SELF])
  and  FRAME("SYSTEMS", #SYS#=[NRS_SYSTEM_COUNTER],
       #PURCH#:=[NRS_SYS_COST_PURCH])
  and FRAME("MD_EUINF", #MD#=[RS_NUM], $RANGE_NOME$:=[NRS_NAME])
 and  [MOD_NUM] IS GIVEN THE VALUE ([MOD_NUM]+1)
  and        FRAME("NUMBERS.FRM",    $ITEM$="Sub-Modules",
#NUM#:=[MOD_NUM])
   and       FRAME("MD_EUINF",    #MD#=[MOD_NUM],
$NOME$:=[NRS_SYS_MOD_NAME])
  and        FRAME("SY_MOD",    #SYS#=[NRS_SYSTEM_COUNTER],
#RS#:=[RS_NUM])
   and       FRAME("SY_MOD",    #RS#=[RS_NUM],
$SYS_NAME$:=[NRS_SYS_MOD_NAME])
   and       FRAME("SY_MOD",    #RS#=[RS_NUM],
#MODULE_RANGE.[[RS_NUM]]#:=1)
  and FRAME("SY_MOD", #RS#=[RS_NUM], #MODULES.[[MOD_NUM]]B#:=1)
  and  [E] IS GIVEN THE VALUE 2
  and        FRAME("SY_EQUIP",    #SYS#=[NRS_SYSTEM_COUNTER],
#RS#:=[RS_NUM])
   and       FRAME("SY_EQUIP",    #RS#=[RS_NUM],
$SYS_NAME$:=[NRS_SYS_MOD_NAME])
  and        FRAME("SY_MATER",    #SYS#=[NRS_SYSTEM_COUNTER],
#RS#:=[RS_NUM])
   and       FRAME("SY_MATER",    #RS#=[RS_NUM],
$SYS_NAME$:=[NRS_SYS_MOD_NAME])
  and        FRAME("SY_TOOLS",    #SYS#=[NRS_SYSTEM_COUNTER],
#RS#:=[RS_NUM])
  and        FRAME("SY_LABOR",    #SYS#=[NRS_SYSTEM_COUNTER],
#RS#:=[RS_NUM])
   and       FRAME("SY_LABOR",    #RS#=[RS_NUM],
$SYS_NAME$:=[NRS_SYS_MOD_NAME])
  and  FRAME("COST_FAC", #RS#=[RS_NUM], $NAME$:=[NRS_NAME])
  and  FRAME("NUMBERS.FRM", $ITEM$="Clim_chg", #NUM#:=1)
  and  FRAME("CLIMATE2", #NO#=[RS_NUM], $NAME$:=[NRS_NAME])
   and       FRAME("SUPPLIER",    #NO#=[RS_NUM],
$MOD_NAME$:=[NRS_SYS_MOD_NAME])
  and        FRAME("SY_COSTS",    #SYS#=[NRS_SYSTEM_COUNTER],
#RS#:=[RS_NUM])
   and       FRAME("SY_COSTS",    #RS#=[RS_NUM],
$SYS_NAME$:=[NRS_SYS_MOD_NAME])
----------------------------------------
RULE NUMBER: 334
IF:
        Which of the following pitches does the [[NRS_NAME]] have?
Monopitch

THEN:
        FRAME("EXTRAS.FRM", #RS#=[RS_NUM], $MONO$:="Yes")

ELSE:
        FRAME("EXTRAS.FRM", #RS#=[RS_NUM], $MONO$:="No")
```

```
RULE NUMBER: 335
IF:
        Which of the following pitches does the [[NRS_NAME]] have?
Double pitch

THEN:
        FRAME("EXTRAS.FRM", #RS#=[RS_NUM], $DBL$:="Yes")

ELSE:
        FRAME("EXTRAS.FRM", #RS#=[RS_NUM], $DBL$:="No")
----------------------------------------
RULE NUMBER: 336
IF:
        Which of the following pitches does the [[NRS_NAME]] have?
Flat

THEN:
        FRAME("EXTRAS.FRM", #RS#=[RS_NUM], $PITCH.OTHER$:="Yes")

ELSE:
        FRAME("EXTRAS.FRM", #RS#=[RS_NUM], $PITCH.OTHER$:="No")
----------------------------------------
RULE NUMBER: 337
IF:
        Is the [[NRS_NAME]] suitable for temporary housing
purposes? Yes

THEN:
        FRAME("EXTRAS.FRM", #RS#=[RS_NUM], #TEMP#:="Yes")

ELSE:
        FRAME("EXTRAS.FRM", #RS#=[RS_NUM], #TEMP#:="No")
----------------------------------------
RULE NUMBER: 338
IF:
        Is the [[NRS_NAME]] suited for extension purposes? Yes

THEN:
        FRAME("EXTRAS.FRM", #RS#=[RS_NUM], #CORE#:="Yes")

ELSE:
        FRAME("EXTRAS.FRM", #RS#=[RS_NUM], #CORE#:="No")
----------------------------------------
RULE NUMBER: 339
IF:
        Is the [[NRS_NAME]] suited for coastal regions? (i.e. is
it protected
        against corrosion?) Yes

THEN:
        FRAME("EXTRAS.FRM", #RS#=[RS_NUM], #COAST#:="Yes")

ELSE:
        FRAME("EXTRAS.FRM", #RS#=[RS_NUM], #COAST#:="No")
----------------------------------------
RULE NUMBER: 340
IF:
        Is there a limit on the allowable span? Yes
  and   [NRS_SPAN_ALLOW]>0

THEN:
           FRAME("EXTRAS.FRM",    #RS#=[RS_NUM],
#SPAN#:=[NRS_SPAN_ALLOW])
```

```
RULE NUMBER: 341
IF:
       Is there a limit on the allowable span? No

THEN:
       FRAME("EXTRAS.FRM", #RS#=[RS_NUM], #SPAN#:=0)
----------------------------------------
RULE NUMBER: 342
IF:
       Which of the following materials is the [[NRS_NAME]]
suitable for?
       Concrete blocks

THEN:
       FRAME("EXTRAS.FRM", #RS#=[RS_NUM], $CONC$:="Yes")

ELSE:
       FRAME("EXTRAS.FRM", #RS#=[RS_NUM], $CONC$:="No")
----------------------------------------
RULE NUMBER: 343
IF:
       Which of the following materials is the [[NRS_NAME]]
suitable for?
       Bricks

THEN:
       FRAME("EXTRAS.FRM", #RS#=[RS_NUM], $BRICKS$:="Yes")

ELSE:
       FRAME("EXTRAS.FRM", #RS#=[RS_NUM], $BRICKS$:="No")
----------------------------------------
RULE NUMBER: 344
IF:
       Which of the following materials is the [[NRS_NAME]]
suitable for?
       Non-load bearing material e.g. sheeting, cardboard etc.

THEN:
       FRAME("EXTRAS.FRM", #RS#=[RS_NUM], $WALLS.OTHER$:="Yes")

ELSE:
       FRAME("EXTRAS.FRM", #RS#=[RS_NUM], $WALLS.OTHER$:="No")
----------------------------------------
RULE NUMBER: 345
IF:
       With regards to the ceiling, classify the [[NRS_NAME]]:
A ceiling is
       included

THEN:
       FRAME("EXTRAS.FRM", #RS#=[RS_NUM], $CEILING.INCL$:="Yes")

ELSE:
       FRAME("EXTRAS.FRM", #RS#=[RS_NUM], $CEILING.INCL$:="No")
----------------------------------------
RULE NUMBER: 346
IF:
       With regards to the ceiling, classify the [[NRS_NAME]]:
Facilities are
       available so as to incorporate a ceiling

THEN:
       FRAME("EXTRAS.FRM", #RS#=[RS_NUM], $CEILING.FAC$:="Yes")

ELSE:
       FRAME("EXTRAS.FRM", #RS#=[RS_NUM], $CEILING.FAC$:="No")
```

```
RULE NUMBER: 347
IF:
        With regards to gutters, classify the [[NRS_NAME]]:
Gutters are
        included

THEN:
        FRAME("EXTRAS.FRM", #RS#=[RS_NUM], $GUTTER.INCL$:="Yes")

ELSE:
        FRAME("EXTRAS.FRM", #RS#=[RS_NUM], $GUTTER.INCL$:="No")
-----------------------------------------
RULE NUMBER: 348
IF:
        With regards to gutters, classify the [[NRS_NAME]]:
Facilities are
        available to incorporate gutters

THEN:
        FRAME("EXTRAS.FRM", #RS#=[RS_NUM], $GUTTER.FAC$:="Yes")

ELSE:
        FRAME("EXTRAS.FRM", #RS#=[RS_NUM], $GUTTER.FAC$:="No")
-----------------------------------------
RULE NUMBER: 349
IF:
        Is the [[NRS_NAME]] a unit or a system? ^^Unit^^

THEN:
         FRAME("UNITS",     #NO#=([LAST_FINISH]+[SU_COUNTER]),
#RS#:=[RS_NUM])
  and   FRAME("UNITS", #NO#=([LAST_FINISH]+[SU_COUNTER]),
        #UNIT#:=[NRS_UNIT_COUNTER])
  and   FRAME("UNITS", #NO#=([LAST_FINISH]+[SU_COUNTER]),
        $UNIT_NAME$:=[NRS_NAME])
  and   FRAME("UNITS", #NO#=([LAST_FINISH]+[SU_COUNTER]),
        #UNIT_NO#:=[SU_COUNTER])
  and   FRAME("UNITS", #NO#=([LAST_FINISH]+[SU_COUNTER]),
        $UNIT_TYPE$:=[NRS_SU_NAME])
  and   FRAME("UNITS", #NO#=([LAST_FINISH]+[SU_COUNTER]),
        #AREA#:=[NRS_SU_AREA])
  and   FRAME("UNITS", #NO#=([LAST_FINISH]+[SU_COUNTER]),
        #SELF#:=[NRS_COST_SU_SELF])
  and   FRAME("UNITS", #NO#=([LAST_FINISH]+[SU_COUNTER]),
        #ART#:=[NRS_COST_SU_ART])
  and   FRAME("UNITS", #NO#=([LAST_FINISH]+[SU_COUNTER]),
        #CONT#:=[NRS_COST_SU_CONT])
-----------------------------------------
RULE NUMBER: 350
IF:
        Is the [[NRS_NAME]] a unit or a system? ^^Unit^^

THEN:
         FRAME("UN_MOD",    #NO#=([LAST_FINISH]+[SU_COUNTER]),
#RS#:=[RS_NUM])
  and   FRAME("UN_MOD", #NO#=([LAST_FINISH]+[SU_COUNTER]),
        #UNIT#:=[NRS_UNIT_COUNTER])
  and   FRAME("UN_MOD", #NO#=([LAST_FINISH]+[SU_COUNTER]),
        $UNIT_NAME$:=[NRS_NAME])
  and   FRAME("UN_MOD", #NO#=([LAST_FINISH]+[SU_COUNTER]),
        #UNIT_NO#:=[SU_COUNTER])
  and   FRAME("UN_MOD", #NO#=([LAST_FINISH]+[SU_COUNTER]),
        $UNIT_TYPE$:=[NRS_SU_NAME])
  and   FRAME("UN_MOD", #NO#=([LAST_FINISH]+[SU_COUNTER]),
        #MODULE_RANGE.[[RS_NUM]]#:=T)
```

```
RULE NUMBER: 351
IF:
        Is the [[NRS_NAME]] a unit or a system? ^^Unit^^

THEN:
        FRAME("UN_EQUIP",     #NO#=([LAST_FINISH]+[SU_COUNTER]),
#RS#:=[RS_NUM])
  and   FRAME("UN_EQUIP", #NO#=([LAST_FINISH]+[SU_COUNTER]),
        #UNIT#:=[NRS_UNIT_COUNTER])
  and   FRAME("UN_EQUIP", #NO#=([LAST_FINISH]+[SU_COUNTER]),
        $UNIT_NAME$:=[NRS_NAME])
  and   FRAME("UN_EQUIP", #NO#=([LAST_FINISH]+[SU_COUNTER]),
        #UNIT_NO#:=[SU_COUNTER])
  and   FRAME("UN_EQUIP", #NO#=([LAST_FINISH]+[SU_COUNTER]),
        $UNIT_TYPE$:=[NRS_SU_NAME])
----------------------------------------
RULE NUMBER: 352
IF:
        Is the [[NRS_NAME]] a unit or a system? ^^Unit^^

THEN:
        FRAME("UN_MATER",     #NO#=([LAST_FINISH]+[SU_COUNTER]),
#RS#:=[RS_NUM])
  and   FRAME("UN_MATER", #NO#=([LAST_FINISH]+[SU_COUNTER]),
        #UNIT#:=[NRS_UNIT_COUNTER])
  and   FRAME("UN_MATER", #NO#=([LAST_FINISH]+[SU_COUNTER]),
        $UNIT_NAME$:=[NRS_NAME])
  and   FRAME("UN_MATER", #NO#=([LAST_FINISH]+[SU_COUNTER]),
        #UNIT_NO#:=[SU_COUNTER])
  and   FRAME("UN_MATER", #NO#=([LAST_FINISH]+[SU_COUNTER]),
        $UNIT_TYPE$:=[NRS_SU_NAME])
----------------------------------------
RULE NUMBER: 353
IF:
        Is the [[NRS_NAME]] a unit or a system? ^^Unit^^

THEN:
        FRAME("UN_TOOLS",     #NO#=([LAST_FINISH]+[SU_COUNTER]),
#RS#:=[RS_NUM])
  and   FRAME("UN_TOOLS", #NO#=([LAST_FINISH]+[SU_COUNTER]),
        #UNIT#:=[NRS_UNIT_COUNTER])
  and   FRAME("UN_TOOLS", #NO#=([LAST_FINISH]+[SU_COUNTER]),
        $UNIT_NAME$:=[NRS_NAME])
  and   FRAME("UN_TOOLS", #NO#=([LAST_FINISH]+[SU_COUNTER]),
        #UNIT_NO#:=[SU_COUNTER])
  and   FRAME("UN_TOOLS", #NO#=([LAST_FINISH]+[SU_COUNTER]),
        $UNIT_TYPE$:=[NRS_SU_NAME])
----------------------------------------
RULE NUMBER: 354
IF:
        Is the [[NRS_NAME]] a unit or a system? ^^Unit^^

THEN:
        FRAME("UN_LABOR",     #NO#=([LAST_FINISH]+[SU_COUNTER]),
#RS#:=[RS_NUM])
  and   FRAME("UN_LABOR", #NO#=([LAST_FINISH]+[SU_COUNTER]),
        #UNIT#:=[NRS_UNIT_COUNTER])
  and   FRAME("UN_LABOR", #NO#=([LAST_FINISH]+[SU_COUNTER]),
        $UNIT_NAME$:=[NRS_NAME])
  and   FRAME("UN_LABOR", #NO#=([LAST_FINISH]+[SU_COUNTER]),
        #UNIT_NO#:=[SU_COUNTER])
  and   FRAME("UN_LABOR", #NO#=([LAST_FINISH]+[SU_COUNTER]),
        $UNIT_TYPE$:=[NRS_SU_NAME])
----------------------------------------
RULE NUMBER: 355
IF:
```

```
        Is the [[NRS_NAME]] a unit or a system? ^^Unit^^

THEN:
        FRAME("UN_COSTS",     #NO#=([LAST_FINISH]+[SU_COUNTER]),
#RS#:=[RS_NUM])
  and   FRAME("UN_COSTS", #NO#=([LAST_FINISH]+[SU_COUNTER]),
        #UNIT#:=[NRS_UNIT_COUNTER])
  and   FRAME("UN_COSTS", #NO#=([LAST_FINISH]+[SU_COUNTER]),
        $UNIT_NAME$:=[NRS_NAME])
  and   FRAME("UN_COSTS", #NO#=([LAST_FINISH]+[SU_COUNTER]),
        #UNIT_NO#:=[SU_COUNTER])
  and   FRAME("UN_COSTS", #NO#=([LAST_FINISH]+[SU_COUNTER]),
        $UNIT_TYPE$:=[NRS_SU_NAME])
-----------------------------------------
RULE NUMBER: 356
IF:
        Is the [[NRS_NAME]] a unit or a system? ^^Unit^^

THEN:
         FRAME("MD_EUINF",     #MD#=([MOD_NUM]+[BB_COUNTER]),
$NOME$:=[NRS_BB_NAME])
-----------------------------------------
RULE NUMBER: 357
IF:
        [NRS_SU_MOD_DATA]>0

THEN:
        [X] IS GIVEN THE VALUE ([MOD_NUM]+[BB_COUNTER])
    a n d        F R A M E ( " U N _ M O D " ,    # N O # = [ C ] ,
#MODULES.[[X]]#:=[NRS_SU_MOD_DATA])
-----------------------------------------
RULE NUMBER: 358
IF:
        [TL1]="new"

THEN:
        [TL1] IS GIVEN THE VALUE ""
-----------------------------------------
RULE NUMBER: 359
IF:
        [TL2]="new"

THEN:
        [TL2] IS GIVEN THE VALUE ""
-----------------------------------------
RULE NUMBER: 360
IF:
        [TL3]="new"

THEN:
        [TL3] IS GIVEN THE VALUE ""
-----------------------------------------
RULE NUMBER: 361
IF:
        [TL4]="new"

THEN:
        [TL4] IS GIVEN THE VALUE ""
-----------------------------------------
RULE NUMBER: 362
IF:
        [TL5]="new"

THEN:
        [TL5] IS GIVEN THE VALUE ""
```

```
RULE NUMBER: 363
IF:
        [TL6]="new"

THEN:
        [TL6] IS GIVEN THE VALUE ""
----------------------------------------
RULE NUMBER: 364
IF:
        [TL7]="new"

THEN:
        [TL7] IS GIVEN THE VALUE ""
----------------------------------------
RULE NUMBER: 365
IF:
        [TL8]="new"

THEN:
        [TL8] IS GIVEN THE VALUE ""
----------------------------------------
RULE NUMBER: 366
IF:
        [TL9]="new"

THEN:
        [TL9] IS GIVEN THE VALUE ""
----------------------------------------
RULE NUMBER: 367
IF:
        [TL10]="new"

THEN:
        [TL10] IS GIVEN THE VALUE ""
----------------------------------------
RULE NUMBER: 368
IF:
        [TL1]<>"x"
   and  [TL2]<>"x"
   and  [TL3]<>"x"
   and  [TL4]<>"x"
   and  [TL5]<>"x"
   and  [TL6]<>"x"
   and  [TL7]<>"x"
   and  [TL8]<>"x"
   and  [TL9]<>"x"
   and  [TL10]<>"x"
   and  [NRS_ADD_TOOL]="Y"

THEN:
        NRS Tool is to be added

ELSE:
        NRS Tool is not to be added
----------------------------------------
RULE NUMBER: 369
IF:
        NRS Tool is to be added

THEN:
        NRS Tool has been added
   and  [TOOL_NUM] IS GIVEN THE VALUE ([TOOL_NUM]+1)
   and  FRAME("NUMBERS.FRM", $ITEM$="Tools", #NUM#:=[TOOL_NUM])
   and  FRAME("TL_EUINF", #TL#=[TOOL_NUM], $NOME$:=[NRS_NEW_TOOL])

    and        FRAME("SUPPLIER",    #NO#=[TOOL_NUM],
```

```
$TL_NAME$:=[NRS_NEW_TOOL])
-----------------------------------------
RULE NUMBER: 370
IF:
        [EQ1]="new"

THEN:
        [EQ1] IS GIVEN THE VALUE ""
-----------------------------------------
RULE NUMBER: 371
IF:
        [EQ2]="new"

THEN:
        [EQ2] IS GIVEN THE VALUE ""
-----------------------------------------
RULE NUMBER: 372
IF:
        [EQ3]="new"

THEN:
        [EQ3] IS GIVEN THE VALUE ""
-----------------------------------------
RULE NUMBER: 373
IF:
        [EQ4]="new"

THEN:
        [EQ4] IS GIVEN THE VALUE ""
-----------------------------------------
RULE NUMBER: 374
IF:
        [EQ5]="new"

THEN:
        [EQ5] IS GIVEN THE VALUE ""
-----------------------------------------
RULE NUMBER: 375
IF:
        [EQ6]="new"

THEN:
        [EQ6] IS GIVEN THE VALUE ""
-----------------------------------------
RULE NUMBER: 376
IF:
        [EQ7]="new"

THEN:
        [EQ7] IS GIVEN THE VALUE ""
-----------------------------------------
RULE NUMBER: 377
IF:
        [EQ1]<>"x"
  and   [EQ2]<>"x"
  and   [EQ3]<>"x"
  and   [EQ4]<>"x"
  and   [EQ5]<>"x"
  and   [EQ6]<>"x"
  and   [EQ7]<>"x"
  and   [NRS_ADD_EQUIP]="Y"

THEN:
        NRS Equipment is to be added

ELSE:
```

```
       NRS Equipment is not to be added
-----------------------------------------
RULE NUMBER: 378
IF:
       NRS Equipment is to be added

THEN:
       NRS Equipment has been added
  and  [EQUIP_NUM] IS GIVEN THE VALUE ([EQUIP_NUM]+1)
  and        FRAME("NUMBERS.FRM",    $ITEM$="Equipment",
#NUM#:=[EQUIP_NUM])
  and        FRAME("EQ_EUINF",    #EQ#=[EQUIP_NUM],
$NOME$:=[NRS_NEW_EQUIP])
  and        FRAME("SUPPLIER",    #NO#=[EQUIP_NUM],
$EQU_NAME$:=[NRS_NEW_EQUIP])
-----------------------------------------
RULE NUMBER: 379
IF:
       [MT1]="new"

THEN:
       [MT1] IS GIVEN THE VALUE ""
-----------------------------------------
RULE NUMBER: 380
IF:
       [MT2]="new"

THEN:
       [MT2] IS GIVEN THE VALUE ""
-----------------------------------------
RULE NUMBER: 381
IF:
       [MT3]="new"

THEN:
       [MT3] IS GIVEN THE VALUE ""
-----------------------------------------
RULE NUMBER: 382
IF:
       [MT4]="new"

THEN:
       [MT4] IS GIVEN THE VALUE ""
-----------------------------------------
RULE NUMBER: 383
IF:
       [MT5]="new"

THEN:
       [MT5] IS GIVEN THE VALUE ""
-----------------------------------------
RULE NUMBER: 384
IF:
       [MT6]="new"

THEN:
       [MT6] IS GIVEN THE VALUE ""
-----------------------------------------
RULE NUMBER: 385
IF:
       [MT7]="new"

THEN:
       [MT7] IS GIVEN THE VALUE ""
```

```
RULE NUMBER: 386
IF:
        [MT8]="new"

THEN:
        [MT8] IS GIVEN THE VALUE ""
----------------------------------------
RULE NUMBER: 387
IF:
        [MT9]="new"

THEN:
        [MT9] IS GIVEN THE VALUE ""
----------------------------------------
RULE NUMBER: 388
IF:
        [MT10]="new"

THEN:
        [MT10] IS GIVEN THE VALUE ""
----------------------------------------
RULE NUMBER: 389
IF:
        [MT11]="new"

THEN:
        [MT11] IS GIVEN THE VALUE ""
----------------------------------------
RULE NUMBER: 390
IF:
        [MT12]="new"

THEN:
        [MT12] IS GIVEN THE VALUE ""
----------------------------------------
RULE NUMBER: 391
IF:
        [MT13]="new"

THEN:
        [MT13] IS GIVEN THE VALUE ""
----------------------------------------
RULE NUMBER: 392
IF:
        [MT14]="new"

THEN:
        [MT14] IS GIVEN THE VALUE ""
----------------------------------------
RULE NUMBER: 393
IF:
        [MT15]="new"

THEN:
        [MT15] IS GIVEN THE VALUE ""
----------------------------------------
RULE NUMBER: 394
IF:
        [MT1]<>"x"
  and   [MT2]<>"x"
  and   [MT3]<>"x"
  and   [MT4]<>"x"
  and   [MT5]<>"x"
  and   [MT6]<>"x"
  and   [MT7]<>"x"
  and   [MT8]<>"x"
```

```
   and   [MT9]<>"x"
   and   [MT10]<>"x"
   and   [MT11]<>"x"
   and   [MT12]<>"x"
   and   [MT13]<>"x"
   and   [MT14]<>"x"
   and   [MT15]<>"x"
   and   [NRS_ADD_MAT]="Y"

THEN:
       NRS Material is to be added

ELSE:
       NRS Material is not to be added
-----------------------------------------
RULE NUMBER: 395
IF:
       NRS Material is to be added

THEN:
       NRS Material has been added
  and  [MAT_NUM] IS GIVEN THE VALUE ([MAT_NUM]+1)
  and  FRAME("NUMBERS.FRM", $ITEM$="Materials", #NUM#:=[MAT_NUM])

  and  FRAME("MT_EUINF", #MT#=[MAT_NUM], $NOME$:=[NRS_NEW_MAT])
   and       FRAME("MT_EUINF",    #MT#=[MAT_NUM],
$UNIT$:=[NRS_NEW_MAT_UNITS])
   and       FRAME("SUPPLIER",    #NO#=[MAT_NUM],
$MAT_NAME$:=[NRS_NEW_MAT])
-----------------------------------------
RULE NUMBER: 396
IF:
       [LB1]="new"

THEN:
       [LB1] IS GIVEN THE VALUE ""
-----------------------------------------
RULE NUMBER: 397
IF:
       [LB2]="new"

THEN:
       [LB2] IS GIVEN THE VALUE ""
-----------------------------------------
RULE NUMBER: 398
IF:
       [LB3]="new"

THEN:
       [LB3] IS GIVEN THE VALUE ""
-----------------------------------------
RULE NUMBER: 399
IF:
       [LB4]="new"

THEN:
       [LB4] IS GIVEN THE VALUE ""
-----------------------------------------
RULE NUMBER: 400
IF:
       [LB5]="new"

THEN:
       [LB5] IS GIVEN THE VALUE ""
```

```
RULE NUMBER: 401
IF:
        [LB6]="new"

THEN:
        [LB6] IS GIVEN THE VALUE ""
----------------------------------------
RULE NUMBER: 402
IF:
        [LB7]="new"

THEN:
        [LB7] IS GIVEN THE VALUE ""
----------------------------------------
RULE NUMBER: 403
IF:
        [LB8]="new"

THEN:
        [LB8] IS GIVEN THE VALUE ""
----------------------------------------
RULE NUMBER: 404
IF:
        [LB1]<>"x"
  and   [LB2]<>"x"
  and   [LB3]<>"x"
  and   [LB4]<>"x"
  and   [LB5]<>"x"
  and   [LB6]<>"x"
  and   [LB7]<>"x"
  and   [LB8]<>"x"
  and   [NRS_ADD_LAB]="Y"

THEN:
        NRS Labour is to be added

ELSE:
        NRS Labour is not to be added
----------------------------------------
RULE NUMBER: 405
IF:
        NRS Labour is to be added

THEN:
        NRS Labour has been added
  and   [LAB_NUM] IS GIVEN THE VALUE ([LAB_NUM]+1)
  and   FRAME("NUMBERS.FRM", $ITEM$="Labour", #NUM#:=[LAB_NUM])
  and   FRAME("LB_EUINF", #LB#=[LAB_NUM], $NOME$:=[NRS_NEW_LAB])
   and        FRAME("SUPPLIER",    #NO#=[LAB_NUM],
$LAB_NAME$:=[NRS_NEW_LAB])
----------------------------------------
RULE NUMBER: 406
IF:
        Is the [[NRS_NAME]] a unit or a system? ^^Unit^^
  and   Is/are   a/any   [[EQUIP_NAME]]/s   required   for   the
[[NRS_SU_NAAM]]? Yes
  and   [NRS_EQUIP_NO_DATA]>0
  and   [NRS_EQUIP_HOURS_DATA]>0
  and   [NRS_EQUIP_DAY_DATA]>0

THEN:
        FRAME("UN_EQUIP", #NO#=[C],
        #EQUIPMENT.[[COUNTER]].H#:=[NRS_EQUIP_HOURS_DATA])
  and   FRAME("UN_EQUIP", #NO#=[C],
        #EQUIPMENT.[[COUNTER]].D#:=[NRS_EQUIP_DAY_DATA])
  and   FRAME("UN_EQUIP", #NO#=[C],
```

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      #EQUIPMENT.[[COUNTER]].N#:=[NRS_EQUIP_NO_DATA])
  and  [COUNTER] IS GIVEN THE VALUE ([COUNTER]+1)
-----------------------------------------
RULE NUMBER: 407
IF:
      Is the [[NRS_NAME]] a unit or a system? ^^Unit^^
  and   Is/are   a/any   [[EQUIP_NAME]]/s   required  for  the
[[NRS_SU_NAAM]]? No

THEN:
      [COUNTER] IS GIVEN THE VALUE ([COUNTER]+1)
-----------------------------------------
RULE NUMBER: 408
IF:
      Is the [[NRS_NAME]] a unit or a system? ^^Unit^^
  and   Is/are   a/any   [[EQUIP_NAME]]/s   required  for  the
[[NRS_SU_NAAM]]? Yes
  and  [NRS_EQUIP_HOURS_DATA]>0

THEN:
       [NRS_EQUIP_DAY_DATA]   IS   GIVEN   THE   VALUE
([NRS_EQUIP_HOURS_DATA]/8)
-----------------------------------------
RULE NUMBER: 409
IF:
      Is the [[NRS_NAME]] a unit or a system? ^^System^^
  and   Is/are   a/any   [[EQUIP_NAME]]/s   required  for  the
[[NRS_NAME]] if the
      [[NRS_SYS_MOD_NAME]] are self-built? Yes
  and  [NRS_EQUIP_SB_NO]>0
  and  [NRS_EQUIP_SB_HOURS]>0
  and  [NRS_EQUIP_SB_DAY]>0

THEN:
      FRAME("SY_EQUIP", #RS#=[RS_NUM],
      #EQUIPMENT.[[COUNTER]]S.H#:=[NRS_EQUIP_SB_HOURS])
  and FRAME("SY_EQUIP", #RS#=[RS_NUM],
      #EQUIPMENT.[[COUNTER]]S.D#:=[NRS_EQUIP_SB_DAY])
  and FRAME("SY_EQUIP", #RS#=[RS_NUM],
      #EQUIPMENT.[[COUNTER]]S.N#:=[NRS_EQUIP_SB_NO])
-----------------------------------------
RULE NUMBER: 410
IF:
      Is the [[NRS_NAME]] a unit or a system? ^^System^^
  and   Is/are   a/any   [[EQUIP_NAME]]/s   required  for  the
[[NRS_NAME]] if the
      [[NRS_SYS_MOD_NAME]] are purchased? Yes
  and  [NRS_EQUIP_PUR_NO]>0
  and  [NRS_EQUIP_PUR_HOURS]>0
  and  [NRS_EQUIP_PUR_DAY]>0

THEN:
      FRAME("SY_EQUIP", #RS#=[RS_NUM],
      #EQUIPMENT.[[COUNTER]]B.H#:=[NRS_EQUIP_PUR_HOURS])
  and FRAME("SY_EQUIP", #RS#=[RS_NUM],
      #EQUIPMENT.[[COUNTER]]B.D#:=[NRS_EQUIP_PUR_HOURS])
  and FRAME("SY_EQUIP", #RS#=[RS_NUM],
      #EQUIPMENT.[[COUNTER]]B.N#:=[NRS_EQUIP_PUR_NO])
-----------------------------------------

RULE NUMBER: 411
IF:
      Is the [[NRS_NAME]] a unit or a system? ^^System^^
  and   Is/are   a/any   [[EQUIP_NAME]]/s   required  for  the
[[NRS_NAME]] if the
      [[NRS_SYS_MOD_NAME]] are self-built? Yes OR No
```

```
  and   Is/are   a/any   [[EQUIP_NAME]]/s   required for the
[[NRS_NAME]] if the
       [[NRS_SYS_MOD_NAME]] are purchased? Yes OR No

THEN:
       [COUNTER] IS GIVEN THE VALUE ([COUNTER]+1)
----------------------------------------
RULE NUMBER: 412
IF:
       Is the [[NRS_NAME]] a unit or a system? ^^System^^
  and   Is/are   a/any   [[EQUIP_NAME]]/s   required for the
[[NRS_NAME]] if the
       [[NRS_SYS_MOD_NAME]] are self-built? Yes
  and  [NRS_EQUIP_SB_HOURS]>0

THEN:
       [NRS_EQUIP_SB_DAY]   IS   GIVEN   THE   VALUE
([NRS_EQUIP_SB_HOURS]/8)
----------------------------------------
RULE NUMBER: 413
IF:
       Is the [[NRS_NAME]] a unit or a system? ^^System^^
  and   Is/are   a/any   [[EQUIP_NAME]]/s   required for the
[[NRS_NAME]] if the
       [[NRS_SYS_MOD_NAME]] are purchased? Yes
  and  [NRS_EQUIP_PUR_HOURS]>0

THEN:
       [NRS_EQUIP_PUR_DAY]   IS   GIVEN   THE   VALUE
([NRS_EQUIP_PUR_HOURS]/8)
----------------------------------------
RULE NUMBER: 414
IF:
       Is the [[NRS_NAME]] a unit or a system? ^^Unit^^
  and   Is/are   a/any   [[MAT_NAME]]/s   required for the
[[NRS_SU_NAAM]]? Yes
  and  [NRS_MAT_NO_DATA]>0

THEN:
          F R A M E ( " U N _ M A T E R " ,   # N O # = [ C ] ,
#MATERIAL.[[COUNTER]]#:=[NRS_MAT_NO_DATA])
  and  [COUNTER] IS GIVEN THE VALUE ([COUNTER]+1)
----------------------------------------
RULE NUMBER: 415
IF:
       Is the [[NRS_NAME]] a unit or a system? ^^Unit^^
  and   Is/are   a/any   [[MAT_NAME]]/s   required for the
[[NRS_SU_NAAM]]? No

THEN:
       [COUNTER] IS GIVEN THE VALUE ([COUNTER]+1)
----------------------------------------
RULE NUMBER: 416
IF:
       Is the [[NRS_NAME]] a unit or a system? ^^System^^
  and   Is/are   a/any   [[MAT_NAME]]/s   required for the
[[NRS_NAME]] if the
       [[NRS_SYS_MOD_NAME]] are self-built? Yes
  and  [NRS_MAT_SB_NO]>0

THEN:
       FRAME("SY_MATER", #RS#=[RS_NUM],
       #MATERIAL.[[COUNTER]]S#:=[NRS_MAT_SB_NO])
----------------------------------------
RULE NUMBER: 417
IF:
```

```
      Is the [[NRS_NAME]] a unit or a system? ^^System^^
  and   Is/are   a/any   [[MAT_NAME]]/s   required  for  the
[[NRS_NAME]] if the
      [[NRS_SYS_MOD_NAME]] are purchased? Yes
  and  [NRS_MAT_PUR_NO]>0

THEN:
      FRAME("SY_MATER", #RS#=[RS_NUM],
      #MATERIAL.[[COUNTER]]B#:=[NRS_MAT_PUR_NO])
----------------------------------------
RULE NUMBER: 418
IF:
      Is the [[NRS_NAME]] a unit or a system? ^^System^^
  and   Is/are   a/any   [[MAT_NAME]]/s   required  for  the
[[NRS_NAME]] if the
      [[NRS_SYS_MOD_NAME]] are self-built? Yes OR No
  and   Is/are   a/any   [[MAT_NAME]]/s   required  for  the
[[NRS_NAME]] if the
      [[NRS_SYS_MOD_NAME]] are purchased? Yes OR No

THEN:
      [COUNTER] IS GIVEN THE VALUE ([COUNTER]+1)
----------------------------------------
RULE NUMBER: 419
IF:
      Is the [[NRS_NAME]] a unit or a system? ^^Unit^^
  and   Is/are   a/any   [[TOOL_NAME]]/s   required  for  the
[[NRS_SU_NAAM]]? Yes
  and  [NRS_TOOL_NO_DATA]>0
  and  [NRS_TOOL_HOURS_DATA]>0
  and  [NRS_TOOL_DAY_DATA]>0

THEN:
      FRAME("UN_TOOLS", #NO#=[C],
      #TOOLS.[[COUNTER]].H#:=[NRS_TOOL_HOURS_DATA])
  and      FRAME("UN_TOOLS",   #NO#=[C],
#TOOLS.[[COUNTER]].D#:=[NRS_TOOL_DAY_DATA])
  and      FRAME("UN_TOOLS",   #NO#=[C],
#TOOLS.[[COUNTER]].N#:=[NRS_TOOL_NO_DATA])
  and  [COUNTER] IS GIVEN THE VALUE ([COUNTER]+1)
----------------------------------------
RULE NUMBER: 420
IF:
      Is the [[NRS_NAME]] a unit or a system? ^^Unit^^
  and   Is/are   a/any   [[TOOL_NAME]]/s   required  for  the
[[NRS_SU_NAAM]]? No

THEN:
      [COUNTER] IS GIVEN THE VALUE ([COUNTER]+1)
----------------------------------------
RULE NUMBER: 421
IF:
      Is the [[NRS_NAME]] a unit or a system? ^^Unit^^
  and   Is/are   a/any   [[TOOL_NAME]]/s   required  for  the
[[NRS_SU_NAAM]]? Yes
  and  [NRS_TOOL_HOURS_DATA]>0

THEN:
      [NRS_TOOL_DAY_DATA]   IS   GIVEN   THE   VALUE
([NRS_TOOL_HOURS_DATA]/8)
```

```
RULE NUMBER: 422
IF:
        Is th  [[NRS_NAME]] a unit or a system? ^^System^^
  and    Is/are    a/any    [[TOOL_NAME]]/s    required  for  the
[[NRS_NAME]] if the
        [[NRS_SYS_MOD_NAME]] are self-built? Yes
  and   [NRS_TOOL_SB_NO]>0
  and   [NRS_TOOL_SB_HOURS]>0
  and   [NRS_TOOL_SB_DAY]>0

THEN:
        FRAME("SY_TOOLS", #RS#=[RS_NUM],
        #TOOLS.[[COUNTER]]S.H#:=[NRS_TOOL_SB_HOURS])
  and   FRAME("SY_TOOLS", #RS#=[RS_NUM],
        #TOOLS.[[COUNTER]]S.D#:=[NRS_TOOL_SB_DAY])
  and   FRAME("SY_TOOLS", #RS#=[RS_NUM],
        #TOOLS.[[COUNTER]]S.N#:=[NRS_TOOL_SB_NO])
----------------------------------------
RULE NUMBER: 423
IF:
        Is the [[NRS_NAME]] a unit or a system? ^^System^^
  and    Is/are    a/any    [[TOOL_NAME]]/s    required  for  the
[[NRS_NAME]] if the
        [[NRS_SYS_MOD_NAME]] are purchased? Yes
  and   [NRS_TOOL_PUR_NO]>0
  and   [NRS_TOOL_PUR_HOURS]>0
  and   [NRS_TOOL_PUR_DAY]>0

THEN:
        FRAME("SY_TOOLS", #RS#=[RS_NUM],
        #TOOLS.[[COUNTER]]B.H#:=[NRS_TOOL_PUR_HOURS])
  and   FRAME("SY_TOOLS", #RS#=[RS_NUM],
        #TOOLS.[[COUNTER]]B.D#:=[NRS_TOOL_PUR_DAY])
  and   FRAME("SY_TOOLS", #RS#=[RS_NUM],
        #TOOLS.[[COUNTER]]B.N#:=[NRS_TOOL_PUR_NO])
----------------------------------------
RULE NUMBER: 424
IF:
        Is the [[NRS_NAME]] a unit or a system? ^^System^^
  and    Is/are    a/any    [[TOOL_NAME]]/s    required  for  the
[[NRS_NAME]] if the
        [[NRS_SYS_MOD_NAME]] are self-built? Yes OR No
  and    Is/are    a/any    [[TOOL_NAME]]/s    required  for  the
[[NRS_NAME]] if the
        [[NRS_SYS_MOD_NAME]] are purchased? Yes OR No

THEN:
        [COUNTER] IS GIVEN THE VALUE ([COUNTER]+1)
----------------------------------------
RULE NUMBER: 425
IF:
        Is the [[NRS_NAME]] a unit or a system? ^^System^^
  and    Is/are    a/any    [[TOOL_NAME]]/s    required  for  the
[[NRS_NAME]] if the
        [[NRS_SYS_MOD_NAME]] are self-built? Yes
  and   [NRS_TOOL_SB_HOURS]>0

THEN:
        [NRS_TOOL_SB_DAY]    IS    GIVEN    THE    VALUE
([NRS_TOOL_SB_HOURS]/8)
----------------------------------------
RULE NUMBER: 426
IF:
        Is the [[NRS_NAME]] a unit or a system? ^^System^^
  and    Is/are    a/any    [[TOOL_NAME]]/s    required  for  the
[[NRS_NAME]] if the
```

```
        [[NRS_SYS_MOD_NAME]] are purchased? Yes
  and   [NRS_TOOL_PUR_HOURS]>0

THEN:
        [NRS_TOOL_PUR_DAY]    IS    GIVEN    THE    VALUE
([NRS_TOOL_PUR_HOURS]/8)
-----------------------------------------
RULE NUMBER: 427
IF:
        Is the [[NRS_NAME]] a unit or a system? ^^Unit^^
  and       Are    [[LAB_NAME]]   labourers   required   for   the
[[NRS_SU_NAAM]]? Yes
  and   [NRS_LAB_NO_DATA]>0
  and   [NRS_LAB_HOURS_DATA]>0
  and   [NRS_LAB_DAY_DATA]>0

THEN:
        FRAME("UN_LABOR", #NO#=[C],
        #LABOUR.[[COUNTER]].H#:=[NRS_LAB_HOURS_DATA])
   and          FRAME("UN_LABOR",    #NO#=[C],
#LABOUR.[[COUNTER]].D#:=[NRS_LAB_DAY_DATA])
   and          FRAME("UN_LABOR",    #NO#=[C],
#LABOUR.[[COUNTER]].N#:=[NRS_LAB_NO_DATA])
  and   [COUNTER] IS GIVEN THE VALUE ([COUNTER]+1)
-----------------------------------------
RULE NUMBER: 428
IF:
        Is the [[NRS_NAME]] a unit or a system? ^^Unit^^
  and       Are    [[LAB_NAME]]   labourers   required   for   the
[[NRS_SU_NAAM]]? No

THEN:
        [COUNTER] IS GIVEN THE VALUE ([COUNTER]+1)
-----------------------------------------
RULE NUMBER: 429
IF:
        Is the [[NRS_NAME]] a unit or a system? ^^Unit^^
  and       Are    [[LAB_NAME]]   labourers   required   for   the
[[NRS_SU_NAAM]]? Yes
  and   [NRS_LAB_HOURS_DATA]>0

THEN:
        [NRS_LAB_DAY_DATA]    IS    GIVEN    THE    VALUE
([NRS_LAB_HOURS_DATA]/8)
-----------------------------------------
RULE NUMBER: 430
IF:
        Is the [[NRS_NAME]] a unit or a system? ^^System^^
  and   Are [[LAB_NAME]] labourers required for the [[NRS_NAME]]
if the
        [[NRS_SYS_MOD_NAME]] are self_built? Yes
  and   [NRS_LAB_SB_NO]>0
  and   [NRS_LAB_SB_HOURS]>0
  and   [NRS_LAB_SB_DAY]>0

THEN:
        FRAME("SY_LABOR", #RS#=[RS_NUM],
        #LABOUR.[[COUNTER]]S.H#:=[NRS_LAB_SB_HOURS])
  and   FRAME("SY_LABOR", #RS#=[RS_NUM],
        #LABOUR.[[COUNTER]]S.D#:=[NRS_LAB_SB_DAY])
  and   FRAME("SY_LABOR", #RS#=[RS_NUM],
        #LABOUR.[[COUNTER]]S.N#:=[NRS_LAB_SB_NO])
-----------------------------------------
RULE NUMBER: 431
IF:
        Is the [[NRS_NAME]] a unit or a system? ^^System^^
```

```
  and  Are [[LAB_NAME]] labourers required for the [[NRS_NAME]]
if the
       [[NRS_SYS_MOD_NAME]] are purchased? Yes
  and  [NRS_LAB_PUR_NO]>0
  and  [NRS_LAB_PUR_HOURS]>0
  and  [NRS_LAB_PUR_DAY]>0

THEN:
       FRAME("SY_LABOR", #RS#=[RS_NUM],
       #LABOUR.[[COUNTER]]B.H#:=[NRS_LAB_PUR_HOURS])
  and  FRAME("SY_LABOR", #RS#=[RS_NUM],
       #LABOUR.[[COUNTER]]B.D#:=[NRS_LAB_PUR_DAY])
  and  FRAME("SY_LABOR", #RS#=[RS_NUM],
       #LABOUR.[[COUNTER]]B.N#:=[NRS_LAB_PUR_NO])
----------------------------------------
RULE NUMBER: 432
IF:
       Is the [[NRS_NAME]] a unit or a system? ^^System^^
  and  Are [[LAB_NAME]] labourers required for the [[NRS_NAME]]
if the
       [[NRS_SYS_MOD_NAME]] are self_built? Yes OR No
  and  Are [[LAB_NAME]] labourers required for the [[NRS_NAME]]
if the
       [[NRS_SYS_MOD_NAME]] are purchased? Yes OR No

THEN:
       [COUNTER] IS GIVEN THE VALUE ([COUNTER]+1)
----------------------------------------
RULE NUMBER: 433
IF:
       Is the [[NRS_NAME]] a unit or a system? ^^System^^
  and  Are [[LAB_NAME]] labourers required for the [[NRS_NAME]]
if the
       [[NRS_SYS_MOD_NAME]] are self_built? Yes
  and  [NRS_LAB_SB_HOURS]>0

THEN:
       [NRS_LAB_SB_DAY] IS GIVEN THE VALUE ([NRS_LAB_SB_HOURS]/8)
----------------------------------------
RULE NUMBER: 434
IF:
       Is the [[NRS_NAME]] a unit or a system? ^^System^^
  and  Are [[LAB_NAME]] labourers required for the [[NRS_NAME]]
if the
       [[NRS_SYS_MOD_NAME]] are purchased? Yes
  and  [NRS_LAB_PUR_HOURS]>0

THEN:
       [NRS_LAB_PUR_DAY]   IS   GIVEN   THE   VALUE
([NRS_LAB_PUR_HOURS]/8)
----------------------------------------
RULE NUMBER: 435
IF:
       Is the [[NRS_NAME]] a unit or a system? ^^Unit^^
  and  [NRS_BB_NO]>0

THEN:
       [MOD_NUM] IS GIVEN THE VALUE ([MOD_NUM]+[NRS_BB_NO])
  and       FRAME("NUMBERS.FRM",    $ITEM$="Sub-Modules",
#NUM#:=[MOD_NUM])
----------------------------------------
RULE NUMBER: 436
IF:
       [NRS_CLIM_COUNTER]>=12

THEN:
```

```
       FRAME("CLIMATE2", #NO#=[RS_NUM], $VALUE$:=[NRS_CLIM_SUIT])
----------------------------------------
RULE NUMBER: 437
IF:
       [COASTAL_REG]="SE"
  and  Is the site of your home closer than 15km from the coast
  and  [COASTAL]="No"

THEN:
       Extras are not met
----------------------------------------
RULE NUMBER: 438
IF:
       [COASTAL_REG]="M"
  and  Is the site of your home closer than 15km from the coast
  and  [COASTAL]="No"

THEN:
       Extras are not met
----------------------------------------
RULE NUMBER: 439
IF:
       [COASTAL_REG]="W"
  and  Is the site of your home closer than 15km from the coast
  and  [COASTAL]="No"

THEN:
       Extras are not met

ELSE:
       Extras are met
----------  ----------
RULE NUMBER: 440
IF:
       [SY_TYPE1]="S"

THEN:
       [SY_TYPE] IS GIVEN THE VALUE "self-built"

ELSE:
       [SY_TYPE] IS GIVEN THE VALUE "purchased"
----------------------------------------
RULE NUMBER: 441
IF:
       [SY_FINAL]="Yes"
  and  [SY_TYPE]<>""
  and  [SYS_RESULTS]="Y"

THEN:
       System costing has been viewed
  and  FRAME("SY_COSTS", #SYS#=[SYS], #INVEST#:=0)
  and  FRAME("SY_COSTS", #SYS#=[SYS], $FINAL$:="No")
  and  FRAME("SY_COSTS", #SYS#=[SYS], #FAC_ROW]:=0)
  and  FRAME("SY_COSTS", #SYS#=[SYS], #MODUL#:=0)
  and  FRAME("SY_COSTS", #SYS#=[SYS], #EQUIP#:=0)
  and  FRAME("SY_COSTS", #SYS#=[SYS], #MATER#:=0)
  and  FRAME("SY_COSTS", #SYS#=[SYS], #TOOLS#:=0)
  and  FRAME("SY_COSTS", #SYS#=[SYS], #LABOR#:=0)
  and  FRAME("SY_COSTS", #SYS#=[SYS], #TOTAL#:=0)
----------------------------------------
RULE NUMBER: 442
IF:
       [UN_FINAL]="Yes"
  and  [UN_RESULTS]="Y"

THEN:
```

```
        Unit costing has been viewed
  and   FRAME("UN_COSTS", #NO#=[UN], #INVEST#:=0)
  and   FRAME("UN_COSTS", #NO#=[UN], $FINAL$:="No")
  and   FRAME("UN_COSTS", #NC#=[UN], #FAC_ROW#:=0)
  and   FRAME("UN_COSTS", #NO#=[UN], #MODUL#:=0)
  and   FRAME("UN_COSTS", #NO#=[UN], #EQUIP#:=0)
  and   FRAME("UN_COSTS", #NO#=[UN], #MATER#:=0)
  and   FRAME("UN_COSTS", #NO#=[UN], #TOOLS#:=0)
  and   FRAME("UN_COSTS", #NO#=[UN], #LABOR#:=0)
  and   FRAME("UN_COSTS", #NO#=[UN], #TOTAL#:=0)
-----------------------------------------
RULE NUMBER: 443
IF:
        [CLEAN_SUP]>0

THEN:
        FRAME("SUPPLIERS", #NO#=[X], #MOD_NEW.Y#:=0)
  and   FRAME("SUPPLIERS", #NO#=[X], #MOD_NEW.N#:=0)
-----------------------------------------
RULE NUMBER: 444
IF:
        [MD1]="new"

THEN:
        [MD1] IS GIVEN THE VALUE ""
-----------------------------------------
RULE NUMBER: 445
IF:
        [MD2]="new"

THEN:
        [MD2] IS GIVEN THE VALUE ""
-----------------------------------------
RULE NUMBER: 446
IF:
        [MD3]="new"

THEN:
        [MD3] IS GIVEN THE VALUE ""
-----------------------------------------
RULE NUMBER: 447
IF:
        [MD4]="new"

THEN:
        [MD4] IS GIVEN THE VALUE ""
-----------------------------------------
RULE NUMBER: 448
IF:
        [MD5]="new"

THEN:
        [MD5] IS GIVEN THE VALUE ""
-----------------------------------------
RULE NUMBER: 449
IF:
        [MD6]="new"

THEN:
        [MD6] IS GIVEN THE VALUE ""
-----------------------------------------
RULE NUMBER: 450
IF:
        [MD7]="new"

THEN:
```

```
        [MD7] IS GIVEN THE VALUE ""
----------------------------------------
RULE NUMBER: 451
IF:
        [MD8]="new"

THEN:
        [MD8] IS GIVEN THE VALUE ""
----------------------------------------
RULE NUMBER: 452
IF:
        [MD9]="new"

THEN:
        [MD9] IS GIVEN THE VALUE ""
----------------------------------------
RULE NUMBER: 453
IF:
        [MD10]="new"

THEN:
        [MD10] IS GIVEN THE VALUE ""
----------------------------------------
RULE NUMBER: 454
IF:
        [MD11]="new"

THEN:
        [MD11] IS GIVEN THE VALUE ""
----------------------------------------
RULE NUMBER: 455
IF:
        [MD12]="new"

THEN:
        [MD12] IS GIVEN THE VALUE ""
----------------------------------------
RULE NUMBER: 456
IF:
        [MD13]="new"

THEN:
        [MD13] IS GIVEN THE VALUE ""
----------------------------------------
RULE NUMBER: 457
IF:
        [MD14]="new"

THEN:
        [MD14] IS GIVEN THE VALUE ""
----------------------------------------
RULE NUMBER: 458
IF:
        [MD15]="new"

THEN:
        [MD15] IS GIVEN THE VALUE ""
----------------------------------------
RULE NUMBER: 459
IF:
        [MD16]="new"

THEN:
        [MD16] IS GIVEN THE VALUE ""
```

```
RULE NUMBER: 460
IF:
        [MD17]="new"

THEN:
        [MD17] IS GIVEN THE VALUE ""
-----------------------------------------
RULE NUMBER: 461
IF:
        [MD18]="new"

THEN:
        [MD18] IS GIVEN THE VALUE ""
-----------------------------------------
RULE NUMBER: 462
IF:
        [MD19]="new"

THEN:
        [MD19] IS GIVEN THE VALUE ""
-----------------------------------------
RULE NUMBER: 463
IF:
        [MD20]="new"

THEN:
        [MD20] IS GIVEN THE VALUE ""
-----------------------------------------
RULE NUMBER: 464
IF:
        [RSNO1]="new"

THEN:
        [RSNO1] IS GIVEN THE VALUE ""
-----------------------------------------
RULE NUMBER: 465
IF:
        [RSNO2]="new"

THEN:
        [RSNO2] IS GIVEN THE VALUE ""
-----------------------------------------
RULE NUMBER: 466
IF:
        [RSNO3]="new"

THEN:
        [RSNO3] IS GIVEN THE VALUE ""
-----------------------------------------
RULE NUMBER: 467
IF:
        [RSNO4]="new"

THEN:
        [RSNO4] IS GIVEN THE VALUE ""
-----------------------------------------
RULE NUMBER: 468
IF:
        [RSNO5]="new"

THEN:
        [RSNO5] IS GIVEN THE VALUE ""
```

```
RULE NUMBER: 469
IF:
        [RSNO6]="new"

THEN:
        [RSNO6] IS GIVEN THE VALUE ""
-----------------------------------------
RULE NUMBER: 470
IF:
        [RSNO7]="new"

THEN:
        [RSNO7] IS GIVEN THE VALUE ""
-----------------------------------------
RULE NUMBER: 471
IF:
        [RSNO8]="new"

THEN:
        [RSNO8] IS GIVEN THE VALUE ""
-----------------------------------------
RULE NUMBER: 472
IF:
        [RSNO9]="new"

THEN:
        [RSNO9] IS GIVEN THE VALUE ""
-----------------------------------------
RULE NUMBER: 473
IF:
        [RSNO10]="new"

THEN:
        [RSNO10] IS GIVEN THE VALUE ""
-----------------------------------------
RULE NUMBER: 474
IF:
        [CLEAN_SUP]>0

THEN:
        FRAME("MD_EUINF", #MD#=[X], #OWN#:=0)
  and   FRAME("MD_EUINF", #MD#=[X], #PURCH#:=0)
  and   FRAME("MD_EUINF", #MD#=[X], #NO#:=0)
-----------------------------------------
RULE NUMBER: 475
IF:
        [CLEAN_SUP]>0

THEN:
        FRAME("EQ_EUINF", #EQ#=[X], #OWN#:=0)
  and   FRAME("EQ_EUINF", #EQ#=[X], #PURCH#:=0)
  and   FRAME("EQ_EUINF", #EQ#=[X], #RENT-D#:=0)
  and   FRAME("EQ_EUINF", #EQ#=[X], #RENT-H#:=0)
  and   FRAME("EQ_EUINF", #EQ#=[X], #NO#:=0)
  and   FRAME("SUPPLIER", #NO#=[X], #EQU_NEW.Y#:=0)
  and   FRAME("SUPPLIER", #NO#=[X], #EQU_NEW.N#:=0)
-----------------------------------------
```

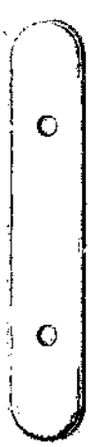
```
RULE NUMBER: 476
IF:
        [CLEAN_SUP]>0

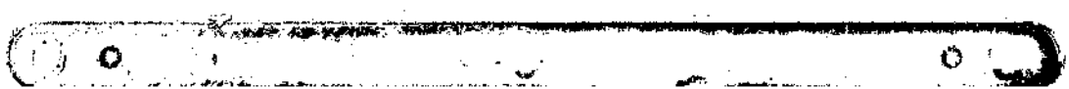
THEN:
        FRAME("MT_EUINF", #MT#=[X], #OWN#:=0)
  and   FRAME("MT_EUINF", #MT#=[X], #PURCH#:=0)
  and   FRAME("MT_EUINF", #MT#=[X], #NO#:=0)
  and   FRAME("SUPPLIER", #NO#=[X], #MAT_NEW.N#:=0)
  and   FRAME("SUPPLIER", #NO#=[X], #MAT_NEW.Y#:=0)
-----------------------------------------
RULE NUMBER: 477
IF:
        [CLEAN_SUP]>0

THEN:
        FRAME("TL_EUINF", #TL#=[X], #OWN#:=0)
  and   FRAME("TL_EUINF", #TL#=[X], #PURCH#:=0)
  and   FRAME("TL_EUINF", #TL#=[X], #RENT-D#:=0)
  and   FRAME("TL_EUINF", #TL#=[X], #RENT-H#:=0)
  and   FRAME("TL_EUINF", #TL#=[X], #NO#:=0)
  and   FRAME("SUPPLIER", #NO#=[X], #TL_NEW.Y#:=0)
  and   FRAME("SUPPLIER", #NO#=[X], #TL_NEW.N#:=0)
-----------------------------------------
RULE NUMBER: 478
IF:
        [CLEAN_SUP]>0

THEN:
        FRAME("LB_EUINF", #LB#=[X], #OWN#:=0)
  and   FRAME("LB_EUINF", #LB#=[X], #RENT-D#:=0)
  and   FRAME("LB_EUINF", #LB#=[X], #RENT-H#:=0)
  and   FRAME("LB_EUINF", #LB#=[X], #NO#:=0)
  and   FRAME("SUPPLIER", #NO#=[X], #LAB_NEW.Y#:=0)
  and   FRAME("SUPPLIER", #NO#=[X], #LAB_NEW.N#:=0)
-----------------------------------------
RULE NUMBER: 479
IF:
        Is there a limit on the allowable span? Yes
  and   [NRS_SPAN_ALLOW]>[MAXISPAN]

THEN:
          FRAME("NUMBERS.FRM",    $ITEM$="Max_span",
#NUM#:=[NRS_SPAN_ALLOW])
```





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