CHAPTER SIX

6.1 CONCLUSION

6.1.1 Structural Consideration

From tables 4.5 and 4.6 of chapter 4 we can conclude that an increase in the steel grade reduces the capacity for the steel to withstand fatigue loading. The experiment shows clearly a reduction in cycles to failure as the steel grades increase. This statement can be shown graphically in the following table and graph.

Table 6.1

Load (KN)	300W failure cycle	350W failure cycle	460W failure cycle
122	1200000	786000	182400
184	322023	60	50

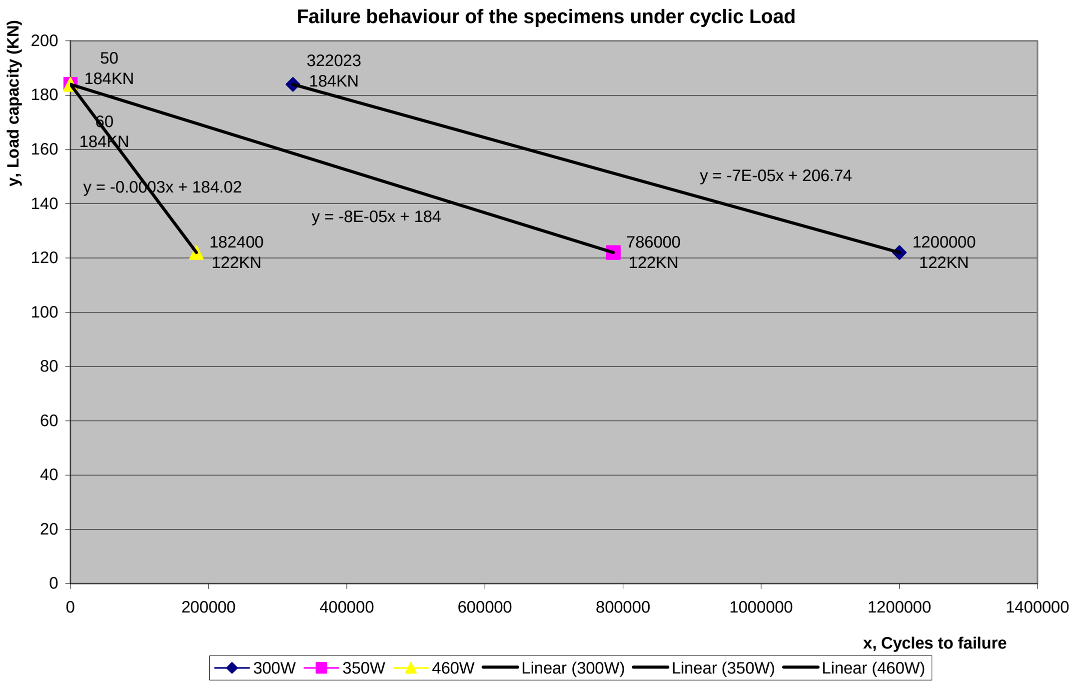

Figure 6.1 – Failure behaviour of specimens under cyclic loading

Graphic equations were derived from the results in order that predictions for various load capacities of the steel grades can be fairly determined. The graph showed a linear relationship because only two load capacities for each steel grade were tested. As a result, estimations for cycles to failure of various load capacities can only be done within the limits of the experiment.

$$For\ 300W,\ y = -7*10^{-05}x + 206.64$$

$$For\ 350W,\ y = -8*10^{-05}x + 184$$

$$For\ 460W,\ y = -0.0003x + 184.02$$

Where x = Cycles to failure and y = Load capacity in KN

Range: 122 KN<y<184 KN

The same condition applies to the failure behaviour when considering the stress applied for various steel grades.

Table 6.2

Stress	300W failure cycle
165	1200000
249	322023
	350W failure cycle
192.3	786000
290	60
	460W failure cycle
251	182400
378	50

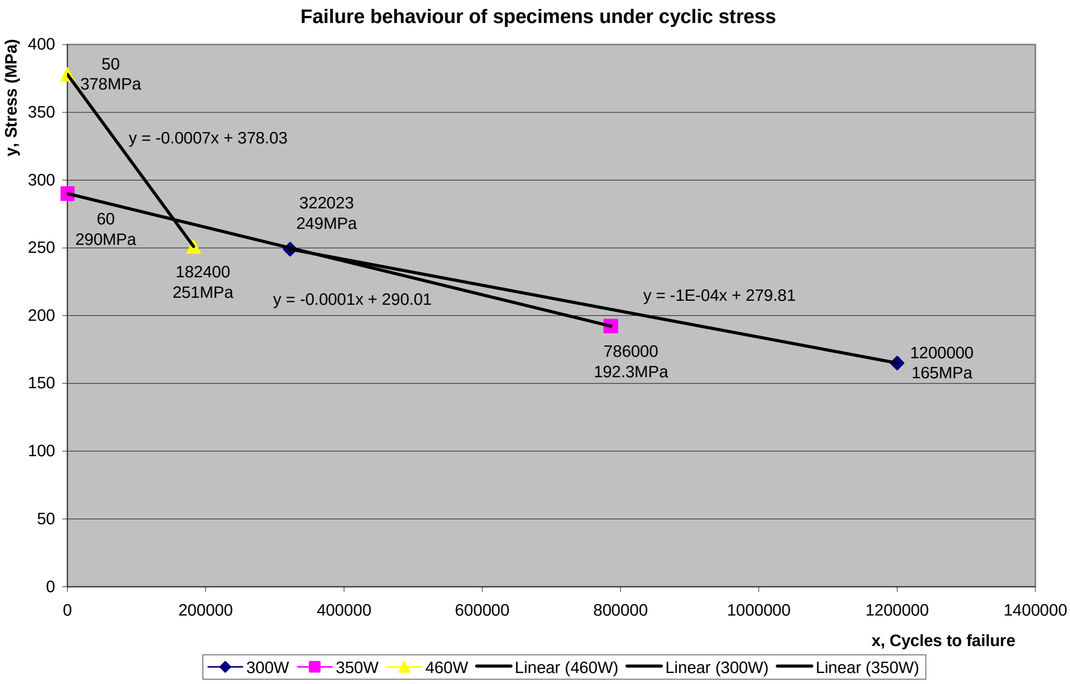

Figure 6.2 – Failure behaviour of specimens under cyclic stress

The equations generated from the stress graph are shown below:

$$For\ 300W,\ y = -1*10^{-04}x + 279.81(165MPa \langle y \langle 249MPa)$$

$$For\ 350W,\ y = -1*10^{-04}x + 290.01(192.3MPa \langle y \langle 290MPa)$$

$$For\ 460W,\ y = -7*10^{-04}x + 378.03(251MPa \langle y \langle 378MPa)$$

Where x = Cycles to failure and y = Stress in N/mm^2 or MPa

A fair idea of the cycles to failure for any grade of steel can easily be determined for any load capacity or stress, provided they are within the ranges given.

Since 350W and 460W @ 184 KN failed within 10 – 10,000 cycles range, they are considered to be low-cycle fatigue experiments, whereas others, 300W @ 122 KN, 300W @ 184 KN, 350W @ 122 KN and 460W @ 122 KN are considered as high-cycle fatigue experiments since their failure occurred above 100, 000 cycles.

The failures occurred instantaneously showing that they all failed as a result of repeated loading still within their elastic region. And all the failures occurred within the zone of loading.

6.1.2 Economic Consideration

The costs per kilogram of various steel grades are listed in the table below:

Table 6.3 – Cost of the various steel grades

Specimen	300W	350W	460W
Cost per Kg (Rands)	5.50	6.50	12.00

Considering the dimensions of the specimens tested:

For 300W:

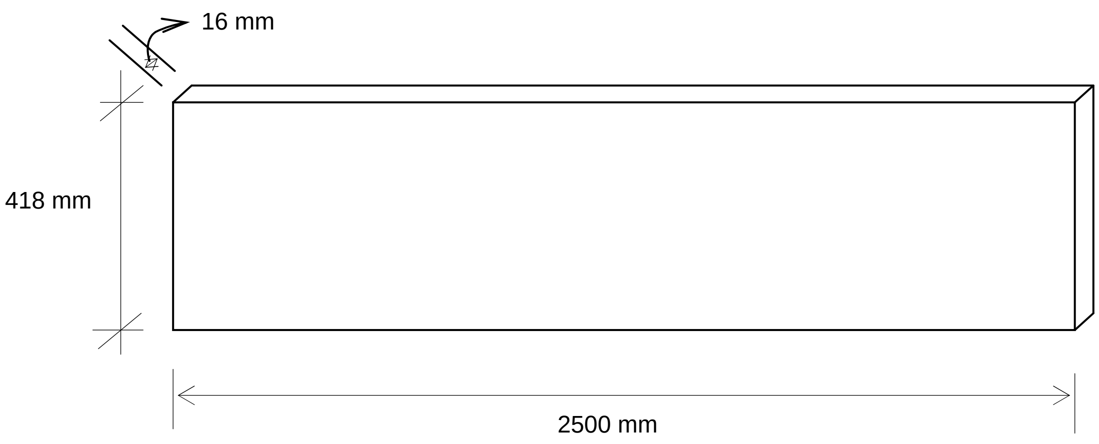

Figure 5.3

$$Volume = 2.5m\,x\,0.418m\,x\,0.016m = 0.01672m^3$$
$$Weight = Volume\,x\,Specific\,Weight$$
$$= 0.01672m^3 x 7800kg/m^3$$
$$= 130.4kg$$
$$\therefore @\,R5.50\ per\ kg$$
$$130.4kg \approx 130.4\,x\,R5.50 = R717.20$$

For 350W:

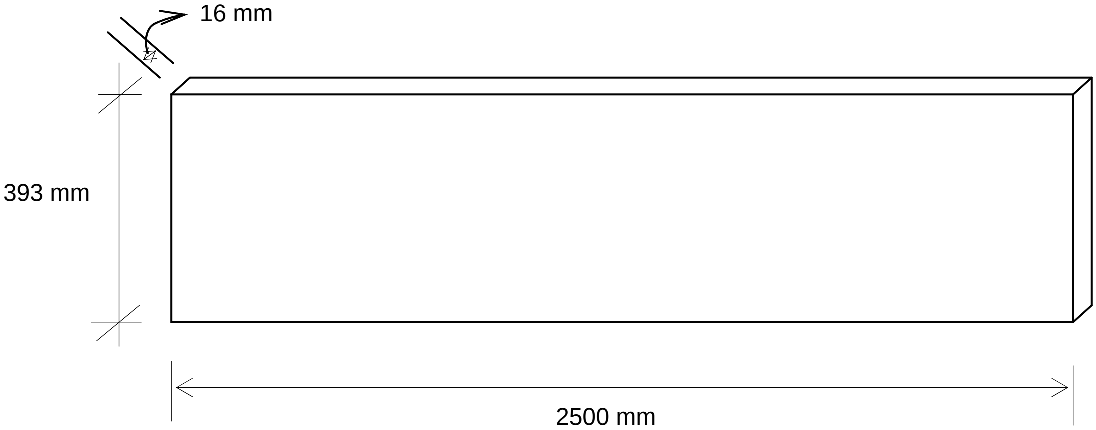

Figure 5.4

$$Volume = 2.5m\,x\,0.393m\,x\,0.016m = 0.01572m^3$$
$$Weight = Volume\,x\,Specific\,Weight$$
$$= 0.01572m^3 x 7800kg/m^3$$
$$= 122.62kg$$
$$\therefore @\,R6.50\ per\ kg$$
$$122.62kg \approx 122.62\,x\,R6.50 = R797.03$$

For 460W:

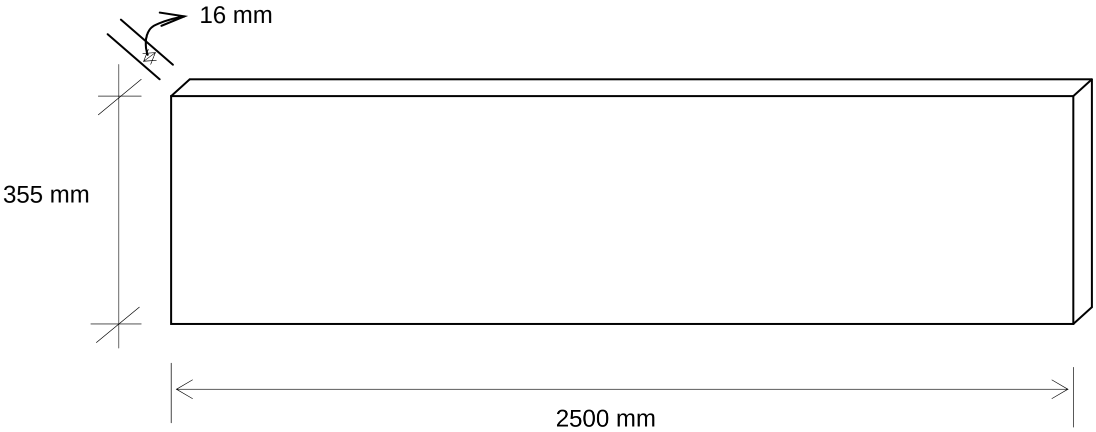

Figure 5.5

$$Volume = 2.5m\,x\,0.355m\,x\,0.016m = 0.0142m^3$$
$$Weight = Volume\,x\,Specific\,Weight$$
$$= 0.0142m^3 x 7800 kg/m^3$$
$$= 110.76kg$$

$$\therefore @\,R12\ per\ kg$$
$$110.76kg \approx 110.76\,x\,R12 = R1329.12$$

Percentage increase in converting from a 300W steel grade to a 350W steel grade:

$$\frac{(797.03 - 717.20)}{717.20} x100 = 11.1\%$$

There will be an 11% increase in the cost of steel material when converting from 300W to 350W steel grade for the erection of any structure. Considering a structure that involves hundreds of metres of steel, an 11% increment in material cost will definitely become uneconomical.

Also, calculating the percentage increase from 300W to 460W gives the following: $\frac{(1329.12 - 717.20)}{717.20} x100 = 85.3\%$

85% increment in cost of steel material will be expected if a 460W is used instead of 300W.

This clearly shows an increase in cost as the steel grade is increased despite its reduction in section and weight.

6.1.3 Selection criteria consideration

After the optimization process, the best optimal grade was 300W. This was due to the fact that:

i) Its horizontal drift was smaller than other grades when analyzed linearly,

ii) It cheaper than other grades,

iii) And its resistance to fatigue is far better than other grades tested.

iv) Articulates well with international trends.

6.2 RECOMMENDATION

Since 350W and 460W @ 184 KN which is 75% of the load capacity failed within the low-cycle fatigue range, it is recommended that a lower load capacity is used for future experiments.

Since only the depth of the webs were altered to meet up with the constant load capacity of the various steel grades, more experiments with varying flange and web lengths should be conducted at every 5% load capacity increment in order to conclusively determine the appropriate curve of the load and stress behaviour, i.e. each specimen should be tested from 0.3P to 0.7P loading and also at varying webs.

Economic consideration has become an important issue in upgrading from a lower steel grade to a higher one, therefore, in order to achieve the purpose of upgrading economically, lower steel grade like the 300W should not be exterminated completely, rather, it should be integrated in design and erection with higher ones like the 350W.