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Catenary vaults: a solution to low-cost housing in South Africa

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Abstract

This research report discusses the design approach of catenary vaults in the application of low-cost housing. It investigates the most efficient design, materials and construction methods to provide a sustainable and durable solution to low-cost housing.

Investigation into various materials was carried out and two specific blocks are used in the construction process: the dry-stack interlocking block and the splitter-brick block.

An innovative method of designing catenary curves was developed: The Segmental Equilibrium Method. This design approach focuses on equilibrium equations to define the geometric shape of a catenary under various loading. The method incorporates dead, live and wind loads. The solution obtained is exact and thus proves to be the most superior method in designing catenary curves. The method was compared to the Finite Element Analysis and errors ranged from 0% to 8.9%. Finite Element collaborated with the Segmental Equilibrium Method and verified that the proposed method of analysis can be used in the design of catenary curves.

Finite Element Method was used to analyse temperature loading on the catenary curve. A tensile stress of 0.95N/mm² and compressive stress of 1.02N/mm² were obtained. These values are within the materials capacity of the brick (1.1N/mm² Tension and 7-10 N/mm² Compression).

The final structure was built using a sliding steel form work. The construction process was closely documented and is discussed in the report. The problems during construction and solutions are presented. A cost analysis was carried out and compared to other leading projects in South Africa. It was found that the structure is economically competitive, with an average cost of R95 000 ($9 500).

The report concludes that thin shelled structures, in particular catenary vaults, are a viable option for low-cost housing in South Africa.