Scientific Journal of Impact Factor (SJIF): 4.14
e-ISSN (O): 2348-4470
p-ISSN (P): 2348-6406
International Journal of Advance Engineering and Research Development
Volume 3, Issue 11, November -2016

COMPARATIVE ANALYSIS OF DIFFERENT DESIGN MODELS OF OVERHEAD STORAGE STEEL TANK (30,000 LITRES) CAPACITY.

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ABSTRACT- This work comprises the documentation of comparative analysis of different design models of overhead storage steel tank (30,000 litres) capacity and 6m height. The total design load used for analysis was gotten from the weight of water when filled to capacity; wind load and self weight of the members were also considered in the load analysis. Five models of the same tank were analysed and designed by varying the span of bracing interval of the bracing members. The model 1 was braced at 1m intervals, model 2 was braced at 1.5m intervals, model 3 was braced at 2m intervals, and model 4 was braced at 3m intervals and finally model 5 was braced at 6m intervals; all models were double diagonal bracing, pinned connected and fixed supported. The beam members were analysed and designed using simple analytical approach. Because of the high degree of statical indeterminacy in the analysis of stanchion and bracing components using manual approach, Computer aided structural analysis software staad pro v8i 2007 version was employed to analyse and generate member force details for stanchion and bracing members of each model tested. The maximum compressive force on the stanchion member of each model was adopted for stanchion design per model. And the maximum force on the bracing member of each model was adopted for bracing design per model. These were used to design each model and select sections required per model. After selection of members for various models designed, total weights were computed per model to establish relationship between span of bracing intervals per model and total weight of steel required per model. This led to a conclusion that longer span of bracing intervals leads to reduction in total weight of steel required and optimal design of over head storage steel tanks. This is due to observed reduction of total weight of steel and reduction in repeated connection cost which most often leads to decrease in total cost.

INTRODUCTION

This research study comparative analysis of different design models of overhead storage steel tank (30,000 litres) capacity was carried with the aim to further improve in the design for structural steelworks to BS5950 for provision of safe and economically viable steel structures.

A structure is a body, composed of several elements so assembled that it can set up resistance against deformation usually caused due to the application of external forces. These forces come into existence as a result of the loads either placed on the structure or as a result of self weight of the structure itself.

A steel structure can be defined as an assembling and construction of steel members capable of resisting applied loads without deformation. Construction of steel structural members/elements gives rise to existence of steel building and other steel structures like steel overhead tanks and ware houses. Steel structural members are mainly subjected to axial forces, tensile or compressive stresses due to loadings.

These primary influences may be accompanied by shear forces, bending moments and some a times torsion. The effects due to changes in temperature, corrosion and the possibility of damages resulting from over loading, local damages, frost attack etc, should be appropriately considered.

Steel structural members comprise of tension members, compression members and members subject to axial loads and bending moment.

Meticulous attention needs to be given to avoid the occurrence of over design which will result in over expenditure in the project. Also unsafe designs which may result to abnormal settlement of the foundation, failure and other instability problems. Steel structural design, tends to be more precise in design assumptions than most materials as it follows hooks law up to a fairly high stress level. Steel structure if well maintained will last indefinitely and it also has the property of withstanding extensive deformation without failure. But if poorly designed it will fail.

Below are common problems associated with design of steel structure:

(i) Economic values that can be saved are wasted when members are selected based on engineers experience rather comparative designs to know which of the design is most economically viable.

(ii) Poor design: In design of steel structure; safety, economy and aesthetics are major factors considered. These will be compromised when the design is not properly done.
(iii) Poor erection procedure/method: This problem is common and is mainly encountered in the decision for the connection method to use (Bolt or weld).

Steel structures are becoming fast growing trend in the field of construction technology. Steel bridges, skyscrapers, roof truss, transmission towers, elevated steel overhead tanks structures and rest of them, steel has been adopted for this numerous use in place of other building materials (like concrete, timber) due to its high strength, behavior under tension and its precision in calculation.

Therefore, the purpose of this study includes

To prevent wastage of economic values through improper member selection by incompetent engineers who usually neglect comparative designs to know the most economical alternatives.

To develop improve designs, to meet satisfactory standard in safety, economy and aesthetic requirements.

To develop adequate and consistent erection procedures and method that will ensure safety and economy of the designed overhead steel tank.

The case study design of elevated overhead water reservoir is undeniably the most common sight of steel structure in Nigeria. The structural design of elevated steel water reservoir structure for safety and economic should be well understood by students of Civil Engineering. This will help them to become expert to meet the demand challenges for most economical design and use of steel section at their ultimate state. This will result in design of more effective, economical and safe steel structures and therefore lead to overall national development.

Without doubt, the most important metal development throughout history has occurred in the manufacture of iron and its famous alloy steel. Steel is defined as a combination of iron with a small amount of carbon, usually less than one percent it also contains small percentages of some other elements like manganese, chromium molybdenum, nickel and copper.

According to Arya (2009), the first large volume process for producing steel was named after Sir Henry Bessemer of England in the eighteenth century. By 1890, steel had become, the principal metal used in the United States of America in the nineteenth century, there was nearly no economically production method available for large volume of steel. The first use of metal for a sizable structure occurred in England in shropshire, in the construction of the 30.6 metres span Coalbrookdale Arch Bridge over the river Severn in the year 1779. In 1890, the first building completely formed with structural steel was completed in Chicago.

The association of America steel manufacture (now, AISI, American iron and steel Institute) made efforts to standardize shapes of structured steel in 1890.

Way and Salter (2006), showed that structural steel can be economically rolled into wide variety shapes and sizes, but the most desirable members are those which have large moments of inertia in proportion to the areas which are mainly I and T sections. Following this development, many varieties of steel structures have been completed and also the use of structural steel in design of elevated overhead tank has always been in place.

In developing countries, like Nigeria the most common sight of steel structures would be in water reservoir structure, transmission tower, micro wave towers, roof trusses and ware houses. But in more technologically advanced countries, there is a non-exhaustible list of steel usage in structure including skyscrapers, steel bridges, etc one might then after seeing these wide and versatile usage of steel as a structure materials and say it is the perfect structural material and yet not too far from the truth.

In the design of any structure, the first step is load analysis. The structure was considered for the dead and live load (GK and QK) from the weight of the empty tank, weight of water in the storage tank and wind load, while keeping in mind the safety for both ultimate and serviceability limit state.

The load from the tank (both tank self weight and water weight in the tank) is directly carried by the secondary beam. The self weight of the secondary beam was also included, then all the loads were converted to uniformly distributed load (udl) .These loads were used to analyze the beam as a beam with simply supported and cantilever on the both sides. The maximum moment is then applied to determine section modulus (that is the elastic section modulus of steel section required).

In view of safety and economy in mind, suitable members were selected from table of section properties. The design procedures found in BS5950; Part 1. The requirement is that the section must satisfy all serviceability and strength capacity checks. Also economy in the sense that over design and wastage of materials should be avoided.

The primary beams carrying the load from secondary beam were idealized as point loads coming from secondary beams. The loads were also converted to uniformly distributed load with simply supports and cantilevers and used to determine bending moments and section properties for the beams. Staad .pro.v8i was used to analyze member forces in the tank stanchions and bracings and beam force detail results were generated for various span variation models tested and sections were selected based on the maximum force to be resisted by the stanchion or bracing. The member force details were outlined in appendix A, 1to 5.

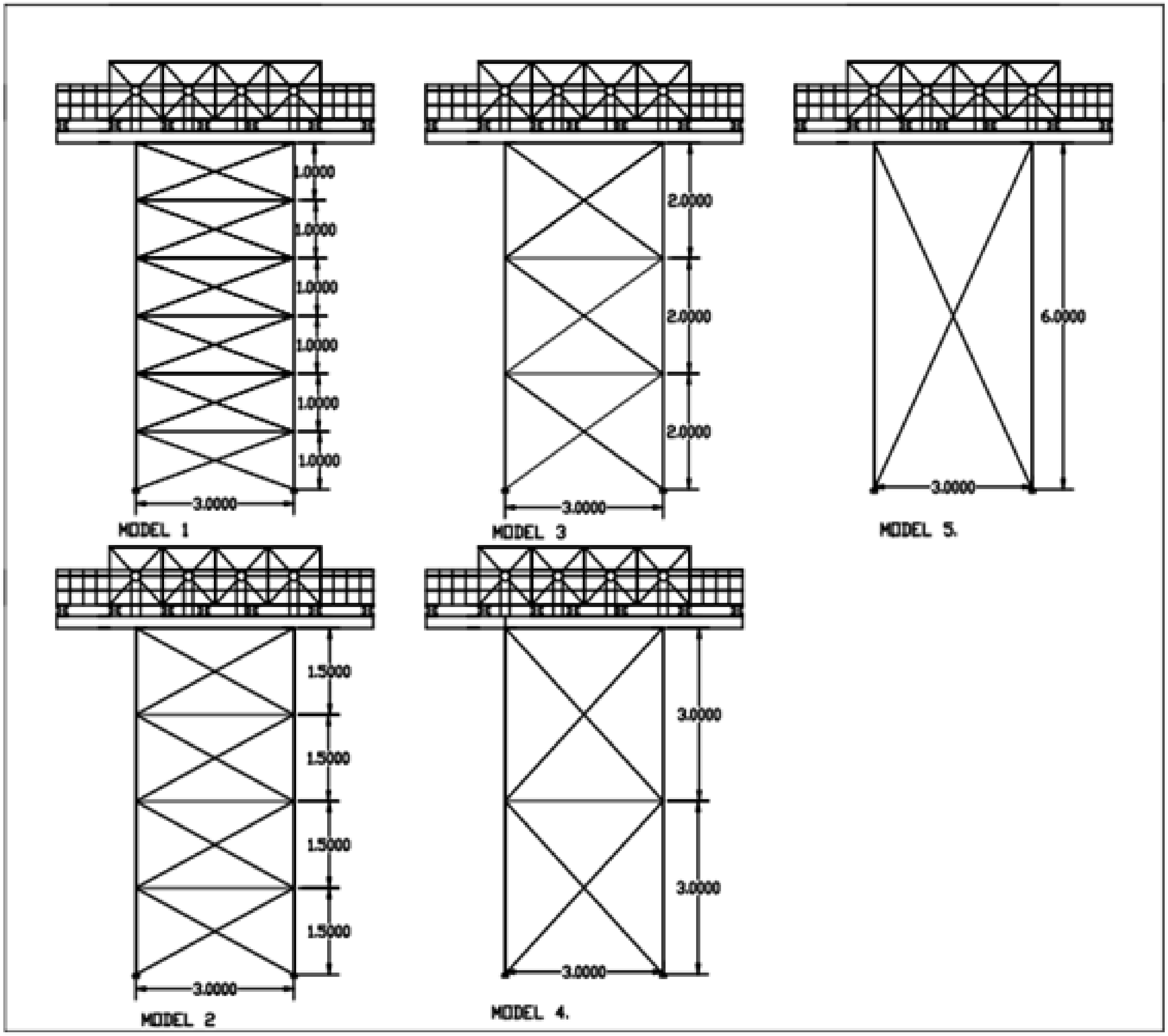
RESEARCH METHODOLGY

The design methodology adopted for this study were five models of stanchion and bracing arrangements. The models storage capacity and total height for the five models were (30,000) thirty thousand litres and height of stanchion was 6metres for each model. Models were established by varying the span intervals of bracing of the stanchion members and analyzing each model to know which span bracing gave the most economically viable sections by providing lightest weight. Loads from tank, primary and secondary beams were transferred to the stanchion and solved pinned connected and fixed supported

Model 1 has bracing spans spaced 1meter intervals
Model 2 has bracing spans spaced 1.5meter intervals
Model 3 has bracing spans spaced 2meter intervals
Model 4 has bracing spans spaced 3meter intervals
Model 5 has bracing spans spaced 6meter interval

Structural members were analysed one by one and the results summarized in a table below. Simple analytical method were employed for the analysis and design of both primary and secondary beams while staad pro v8i structural analysis software were employed for the analysis of the forces in the stanchion and bracing members comparison' were made to identify the model with the most economically viable sections.

Fig.1: Possible models considered in the design



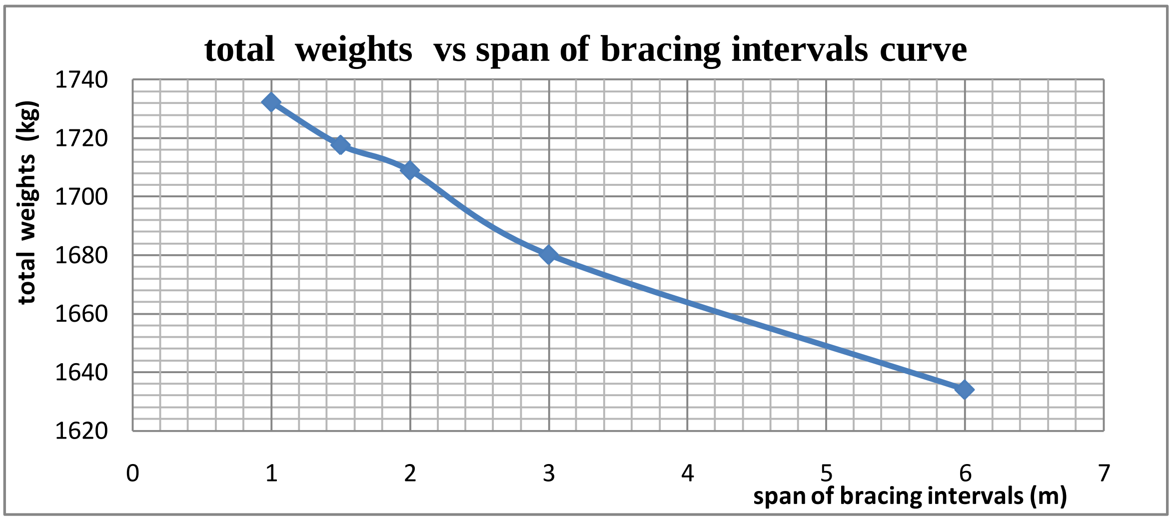
RESULTS AND DISCUSSIONS

TOTAL WEIGHT OF STEEL REQUIRED AND SPAN OF BRACING PER MODEL RELATIONSHIP.

TABLE 1: TOTAL WEIGHT AND SPAN OF BRACING INTERVALS RELATIONSHIP

Model	Span of bracing (m)	Total weight (kg)	Remark
1	1.0	**1732.32128**	Double diagonal bracing
2	1.5	**1717.66016**	Double diagonal bracing
3	2.0	**1708.98464**	Double diagonal bracing
4	3.0	**1680.1776**	Double diagonal bracing
5	6.0	**1634.08448**	Double diagonal bracing

Fig. 2. Total weights against span of bracing intervals curve.



Consideration of the maximum compressive forces on the stanchions and bracing show that forces on the stanchions are relatively high when the stanchions were braced at one metre intervals and decreases when the span of bracing intervals were increased to 1.5m, 2m, 3m and 6m.The forces on bracings also increased when larger span of bracing intervals were designed. The increase in forces directly led to increase in steel sections required because steel sections with high strength capacity were required to sustain force estimated. By going into model weight computations each model was computed for total weight, starting with spans when 1m to when 6metre were considered. The model that has highest weight has also least span of bracing interval .This shows that span of bracing interval should be kept at longer intervals for designing of bracings of overhead steel tanks stanchion for optimum design to be achieved.

This is due to reduction in total length of bracing members when compared to a closely braced stanchion despite increase in unit mass (kg/m) of sections required for bracing members due to increase in forces observed with bracing members of longer span intervals, fig.2

CONCLUSION AND RECOMMENDATION

This research has identified that the wastage of economic values through improper member selection by incompetent engineers who usually neglect comparative designs could be prevented since the most economical alternative is always chosen from the comparative designs.

Increase in the span of bracing intervals led to a decrease in the total weight of steel required in overhead steel tank design. This was due to reductions in the total weight as observed in fig 2. This led to optimum designs because decrease in the total weight of steel required often led to decrease in total cost.

Improved designs that meets satisfactory standard in safety, economy and aesthetic requirements were mostly achieved when the stanchions were braced at relatively longer span intervals. This is due to decrease in both costs resulting from total weight of the steel members required and cost due to repeated connections and maintenance.

The case study design of elevated overhead water reservoir is undeniably the most common type of steel structure in South East Nigeria. The structural design of elevated steel water reservoir structure for safety and economic should be well understood by students of Civil Engineering. This will help them to become expert to meet the demand challenges for most economical design and use of steel section at their ultimate state. Also the overhead storage tank is a very important structure in the communities of which its failure in service can create unnecessary inconveniences to the people. It is therefore imperative for storage tanks to be designed and strictly checked by only registered and competent engineers who have the relevant experience needed for the design and construction of such structures. It is also recommended that other methods of analysis could also be employed to facilitate comparison and appraisal to the one adopted in this study.

REFERENCES.

Arya,C.(2009) Design of Structural Elements.3rd Edition, Spon Press London and New York, Pg 145-148.
Architectural Institute of Japan (2010) Design Recommendation for Storage tanks and Their Supports with Emphasis on Seismic Design, pg 179.
British standard Code of Practice CP3, Chapter V, Wind loads. (1972)
Davison B and Owens G.W.(2003) Steel Designers Manual, Blackwell science ltd UK, Pg1168.
BS5950, (2000) Design in Structural Steelwork Part 1.
Durka F, (2010), Structural mechanics, 7th edition Trans Atlantic publication, Liverpool pg118.
Jericson,A.(2015).Advantages and disadvantages of steel as a structural material.(online). Accessed on may 12,2016 from https://www.scribd.com/doc/272400761/Give-10-Disadvantages-of-steel-as-a structural-material.
Lam D.,Ang T.C, and Chiew S.P(2004) Structural steelwork design to limit state theory 3rd Edition,Elservier Ltd New York Pg180
MacGinley, T.J.(1998) steel structures, Practical Design Studies, 2nd Ed., E and Fn Publishers, UK
McCormac J. C. and Csernak S.F.(2011) Structural steel design 5th edition Pearson, New York city, New York.
MacGinley, T.J and Ang, T. C.(1992) Structural Steelwork: Design to limit state theory, 2nd Ed., Butterworth-Heinemann, Oxford.
Owens G.W. and Cheal,B.D.(1998) Connection, Ist Ed., Butterworths Publication, London.
Pinoy Math Community(2014).stress-strain Diagram.(online). Accessed on May 24th, 2016 from www.mathalino.com/reviewer/mechanics-and-strength-of-materials/stress-strain-diagram
Scalzi, J.B., Lin, T.Y. and Bresler, B.(1968) Desgn of Steel Structures 2nd Ed., Wiley International Edition, London.
Way A.G.J, Salter P R.,(2006) Introduction to steelwork Design to BS5950,1st edition, The steel construction institute silwood park Ascot,pg48.
Wikipedia(2016).The Iron Bridge.(online). Accessed July 30th, 2016 from https://en.m.wikipedia.org/wiki/The-Iron-Bridge.

