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Studies on Large Span Cantilever Structures by using Staad PRO. Analysis

Abhilash Pokkilan, Ramayanapu Rajesh KumarS
Department of Civil Engineering, SVU College of Engineering, Tirupati, India

Abstracts

The main aim of this investigation is to study which section of the large span cantilever structures are more safe and economical among the three sections of pipe, angle and tube. This study focused on the deflections of cantilever spans under different loading conditions such as dead load, live load and wind load and their design details for different spans starting from 8 m span to 20 m span by increasing in the order of 4 m span. During the study the steel take off also varies with the variation in different materials and variation in different spans and observed that the deflections also vary with the variation of spans and elements with two side cantilever structures. On the study the inference is that by comparing the output of STAAD.Pro (structural analysis and design) analysis results of different sections and it is concluded that the steel take off for pipe section is 3% less than tube section in weight and 14% less than angle section in weight. This gives savings 9% in total weight of steel required for frame and concluded that pipe section is more economical when compared to other two sections.

Keywords: Span cantilever, Staad PRO

Introduction

A cantilever is a beam anchored at only one end. The beam carries the load to the support where it is forced against by moment and shear stress. Cantilever construction allows for overhanging structures without external bracing. Cantilevers can also be constructed with trusses or slabs [1]. This is in contrast to a simply supported beam such as those found in a post and lintel system. A simply supported beam is supported at both ends with loads applied between the supports [2].

Cantilevers are widely found in construction, notably in cantilever bridges and balconies (see corbel). In cantilever bridges the cantilevers are usually built as pairs, with each cantilever used to support one end of a central section. The Forth Bridge in Scotland is an example of a cantilever truss bridge. A cantilever in a traditionally timber framed building is called a jetty or fore bay. In the southern United States a historic barn type is the cantilever barn of log construction [3]. Temporary cantilevers are often used in construction. The partially constructed structure creates a cantilever, but the completed structure does not act as a cantilever. This is very helpful when temporary supports, or false work, cannot be used to support the structure while it is being built (e.g., over a busy roadway or river, or in a deep valley). So some truss arch bridges (see Navajo Bridge) are built from each side as cantilevers until the spans reach each other and are then jacked apart to stress them in compression before final joining. Nearly all cable-stayed bridges are built using cantilevers as this is one of their chief advantages. Many box girder bridges are built segmentally, or in short pieces. This type of construction lends itself well to balanced cantilever construction where the bridge is built in both directions from a single support [3].

In an architectural application, Frank Lloyd Wright's Falling water used cantilevers to project large balconies. The East Stand at El land Road Stadium in Leeds was, when completed, the largest cantilever stand in the world holding 17,000 spectators. The roof built over the stands at Old Trafford Football Ground uses a cantilever so that no supports will block views of the field. The old, now demolished Miami Stadium had a similar roof over the spectator area. The largest cantilever in Europe is located at St James' Park in Newcastle-Upon-Tyne, the home stadium of Newcastle United F.C [4].

In the world there are many cantilever concrete structures with large span and the cantilever steel structures are of short span. It is difficult to construct steel structures for large spans without proper detailing of the elements and proper alignment of the structure.

Types of structural elements

Angle section

Steel angle sections are commonly used as beams to support distributed loads which cause biaxial bending and torsion. However, many design codes (BSI, 2000, SA, 1998) do not have any design rules for torsion,

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while some recommendations are unnecessarily conservative when applied to the bending of angle section beams, or are of limited application, or fail to consider some effects which are thought to be important. The behaviour of steel angle sections under biaxial bending and torsion is more complex than that of doubly symmetric sections under uniaxial bending and torsion. The complexity arises from the mono-symmetric or asymmetric nature of angle sections, as well as from the common loading condition in which loading parallel to but eccentric from one of the section legs causes biaxial bending about the principal axes and torsion.

The development of a better understanding of the behaviour of steel angle section beams requires special consideration of their loading and restraint, and of the analysis of their elastic behaviour. Firstly, horizontal restraints of beams with vertical loads acting in the plane of one leg induce significant horizontal forces which modify the elastic stress distribution. These horizontal forces and their effects on the stress distribution need to be accounted for in the elastic analysis of the beam. Secondly, angle section beams are often loaded eccentrically from the shear centre at the intersection of the legs, in which case significant torsion actions may result. These torsion actions need to be accounted for in the analysis.

The strengths of steel angle section beams are related to their section capacities to resist bending, bearing, shear, and torsion actions, and to their member capacities to resist the interactions between biaxial in-plane bending, out-of-plane buckling, and torsion. Very short span beams under distributed loading may fail at the supports, where the shear stresses induced by shear forces and uniform torques are greatest, while long span beams often fail near mid-span, where the normal stresses induced by biaxial bending moments are greatest. (can u write this section briefly and provide corresponding reference like IS code for steel)

Pipe section

A stainless steel pipe system is the product of choice for carrying corrosive or sanitary fluids, slurries and gases, particularly where high pressures, high temperatures or corrosive environments are involved. Due to stainless steel's aesthetic properties, stainless steel pipe is also used in architectural applications. Stainless steel pipe can be generally defined as a heavy wall thickness tubing, with dimensions as specified by the American National Standards Institute (ANSI). Pipe dimensions are specified by outside diameter – indicated by the NPS (imperial) or DN (metric) designator and sometimes referred to as the 'nominal bore'– and wall thickness, reflected in the schedule number. ASME B36.19 covers these dimensions. Stainless steel pipe and fittings are supplied in the annealed condition to facilitate fabrication and ensure best corrosion resistance. Atlas Steels can also supply stainless steel pipe with an abrasive polished finish suitable for architectural applications. (can u provide corresponding reference like IS code for steel)

Tube section

Technical characteristics of steel tubes are detailed in the appropriate technical standards. Tube parameters could be divided into three main groups:

• Dimensions and their tolerances (depending upon the tube manufacturing method)
• Steel grade and steel conditions
• Technical delivery conditions individual national bureaus of standards use different procedures for data standardization of steel pipes.

In real life three options are used:

• Each main group of parameters is contained in a single standard. The standards are interconnected using references to the related ones. Dimensional standard contains dimensional tables and their tolerances; steel standard contains its chemical composition and mechanical properties for various methods of pipe manufacturing and steel tempers. The third standard of the technical delivery conditions (TDC) sets out all remaining requirements for pipes – testing, acceptance, certificates, packaging, marking, etc. At the same time it contains references to other standards where these activities are described (expand the terms STN, CSN).
• The second option is when steel and its characteristics are included into the TDC standard, and this one contains dimensional tolerances. Two standards are used to describe a pipe – dimensional standard that contains dimensional table and the TDC standard. (expand this term)
• The third option – pipe parameters are in a single standard, which also contains the dimensional table, or extraction from the general table of dimensions constituting which is the content of the general dimensional standard. (expand this term)

In real life there are cases, where both the seller and the buyer make bilateral TDC contracts, or they deliver pipes in accordance with the buyer's specifications, which can also include the references to national standards. Normally, this is the case, where the demands for pipes are higher then those set-up in the national standards

Loads on the structure

Dead load

Dead loads are permanent or stationary loads which are transferred to the structure throughout their

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life span. Dead load is primarily due to self weight of structural members, permanent partition walls, fixed permanent equipment and weighs of different materials.

Imposed loads or Live loads

Live loads or movable loads without any acceleration or impact. These are assumed to be produced by the intended use or occupancy of the building including weights of movable partition or furniture etc. The imposed loads are to be assumed in buildings. The live load is 0.5 KN/m2 for inhabitable roof [5].

Impact load

Impact load is caused by vibration or impact or acceleration. A person walking produces a live load but soldiers marching or frames supporting lifts and hoists produce impact loads. Thus impact load is equal to imposed incremented by some percentage depending on the intensity of impact.

Earth quake load

Earth quake loads are horizontal loads caused by earth quake and shall be computed in accordance with IS 1893:2002 [9]. For monolithic reinforced concrete structures located in seismic zone II and III without more than 5 storey high, and importance factor less than 1, the seismic forces are not critical.

Characteristic load

Since the loads are variable in nature they are determined based on statistical approach. But it is impossible to give a guarantee that the loads cannot exceed during the life span of the structure. Thus, the characteristic value of the load is obtained based on statistical probabilistic principles from mean value and standard deviation [4].

The characteristic load is defined as that value of load which has 95% probability of not being exceeded during the service span of the structure. However, this requires large amount of statistical data. Code recommends to take the working loads or service loads based on past experience and judgement and are taken as per IS 8752.1 [8] and IS 18932.3 [9] codes.

Other loads

(Write this section as other loads) 1.5 KN/m^2 wind pressure is considered in both directions [6].

STAAD PRO analysis

STAAD or (STAAD.Pro) is a structural analysis and design computer program originally developed by Research Engineers International in Yorba Linda, CA. In late 2005, Research Engineer International was bought by Bentley Systems.

An older version called Staad-III for windows is used by Iowa State University for educational purposes for civil and structural engineers. The commercial version STAAD.Pro is one of the most widely used structural analysis and design software. It supports several steel, concrete and timber design codes. It can make use of various forms of analysis from the traditional 1st order static analysis, 2nd order p-delta analysis, geometric non linear analysis or a buckling analysis. It can also make use of various forms of dynamic analysis from modal extraction to time history and response spectrum analysis.

In recent years it has become part of integrated structural analysis and design solutions mainly using an exposed API called Open STAAD to access and drive the program using an VB macro system included in the application or other by including Open STAAD functionality in applications that themselves include suitable programmable macro systems. Additionally STAAD.Pro has added direct links to applications such as RAM Connection and STAAD. Foundation to provide engineers working with those applications which handle design post processing not handled by STAAD.Pro itself [10].

Experimental study

This investigation aims to study which section of the large span cantilever structures is more safe and economical among the three sections of pipe, angle and tube. This study focused on the deflections of cantilever spans under different loading conditions such as dead load, live load and wind load and their design details for different spans starting from 8 m span to 20 m span by increasing in the order of 4 m span.

The structure is designed according to IS 800:2007 [7] codal provisions where the design is based on the limiting moment on the structure and its behaviour due to various loads. The best structure for constructing with the minimum deflection and with an economical design is to be determined by this program [7].

The magnitude of loads given on the structure:
Dead Load: self weight of the structure
Live Load: 0.5 KN/m2 for inhabitable roof
Wind load: 1.5 KN/m2 pressure is considered in both directions

(you didn't specify magnitude of any loads and their combinations i.e., how much loads are given and their combinations if any)

Results and discussions

Estimation and rate analysis of the structures

The estimation of the quantities shows the economical section which can be used for construction

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as it depends on the deflection and the forces in the member, this will effect the quantity of the steel required as we use different sections for analyzing the structure.

(Write some lines regarding the results shown in the tables)

Table 1.Estimation of Steel quantity for Construction of the structures ***(write table caption)***

	Estimate (KN)							
	Single Side Cantilever Structure				**Two Side Cantilever Structure**			
	8 m	16 m	12 m	24 m	16 m	32 m	20 m	40 m
Angle	50.56	98.738	59.79	174.535	69.814	242.213	80.74	272.8
Pipe	35.712	68.47	53.547	160.35	60.897	223.623	48.36	184.04
Tube	36.358	69.842	53.653	162.561	62.305	228.25	52.32	192.47

(Have u analyzed span from 8 m to 20 m or 40 m, change accordingly in ur manuscript)

The present rate of the steel in the market is about forty five thousand rupees per metric ton (write in sentence format)

Table 2.Rate analysis of the analyzed structures ***(write table caption)***

	Rates(lakhs)							
	Single Side Cantilever Structure				**Two Side Cantilever Structure**			
	8 m	16 m	12 m	24 m	16 m	32 m	20 m	40 m
Angle	2.27	4.44	2.69	7.86	3.14	10.90	3.63	12.276
Pipe	1.61	3.08	2.41	7.22	2.74	10.06	2.18	8.28
Tube	1.64	3.15	2.42	7.32	2.80	10.27	2.35	8.66

Write subheading title

Table 3.Deflections of the structures due to the loads ***(write table caption)***

	Deflection(mm)							
	Single Side Cantilever Structure				**Two Side Cantilever Structure**			
	8 m	16 m	12 m	24 m	16 m	32 m	20 m	40 m
Angle	17.1	22.6	48.56	25.88	72.94	78.86	92.65	54.72
Pipe	21.28	38.68	56.22	30.13	90.135	123.79	126.48	79.56
Tube	18.8	31.59	53.62	27.84	90.32	119.86	116.9	72.15

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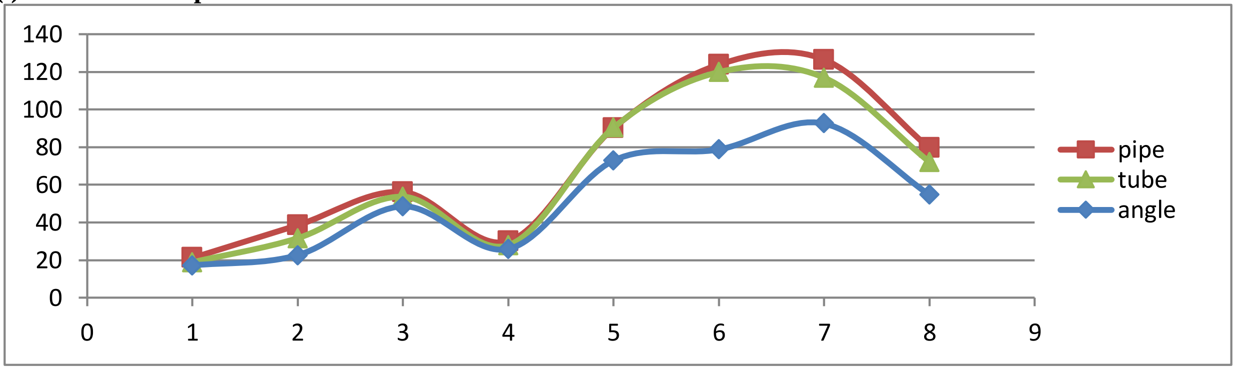
Permissible Deflection=Span(L)/150 mm (By IS 800-2007,pg no.31**)**

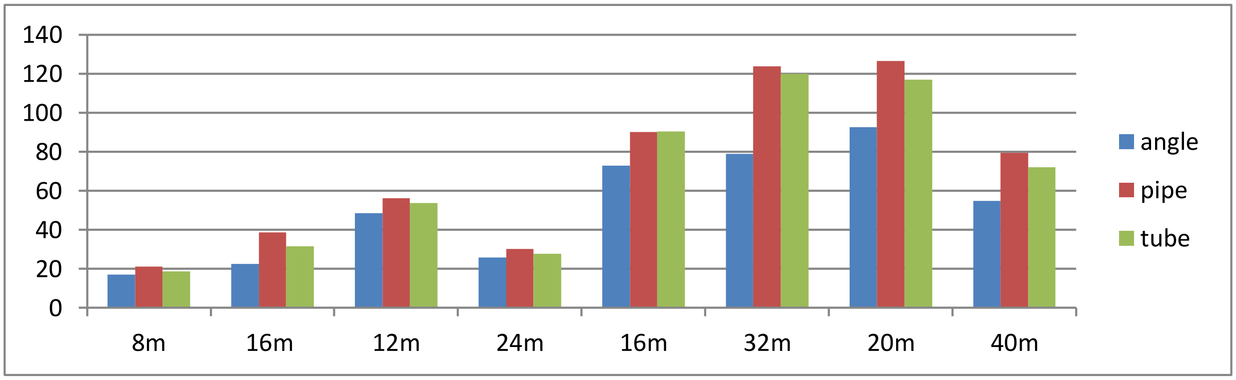
Table 4. Permissible Deflections table for the structures

	Deflection(mm)							
	Single Side Cantilever Structure				**Two Side Cantilever Structure**			
	8m	16m	12m	24m	16m	32m	20m	40m
angle	53.33	106.67	80	160	106.67	213.33	133.33	266.67
pipe	53.33	106.67	80	160	106.67	213.33	133.33	266.67
tube	53.33	106.67	80	160	106.67	213.33	133.33	266.67

Results represented in graph

(i) Deflection Graphs:





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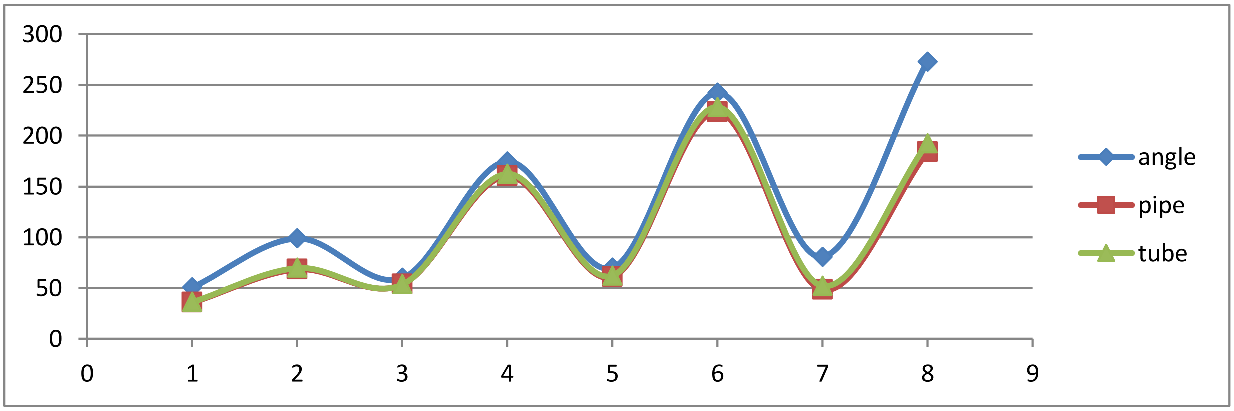
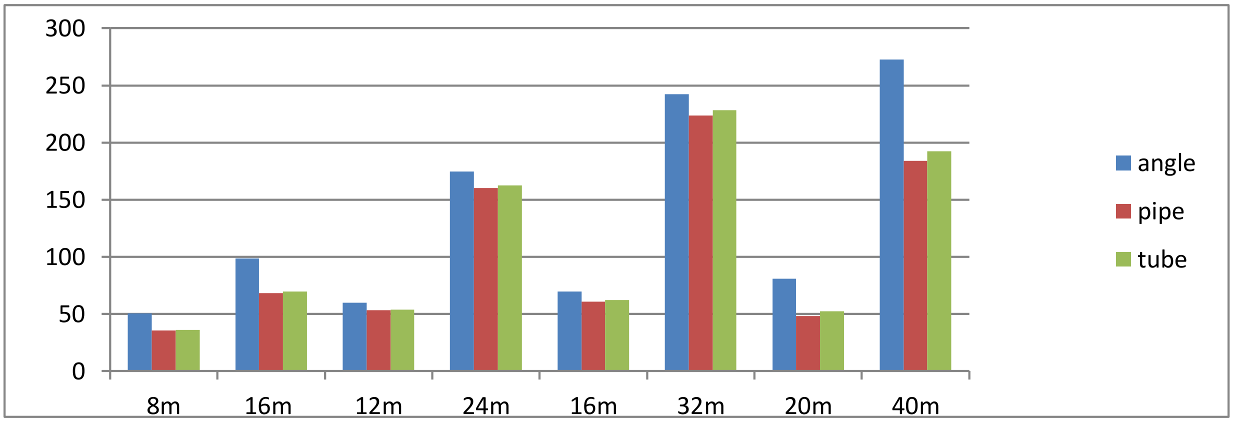
(ii) Estimation Graphs:





From these results it can be stated that the economic section is the tubular section which has both deflection and cost in the permissible limits

As the forces in the pipe are less the bearing connections required are of less strength which ultimately reduce the cost of the project

The Steel take off also varies with the variation in different materials and variation in different spans.

The Deflections also vary with the variation in spans and elements and with two side cantilever structure.

The pipe has less deflections compared to tube and the cost of construction is also less compared to the other two structures which makes it more useful for construction.

(Please interpret the results properly and mention how pipe section is safe and economic when comparing to other. Plz look at other journal results and discussions for write up)

Conclusions

- By comparing the output of staad pro design results of different sections such as tube, pipe and angular sections it is concluded that, the steel take off for pipe section is 3% less than tube section in weight & 14% less than angle section in weight when compared to other two sections. This gives savings 9% in total weight of steel required for frame
- The Support reactions, axial forces, moments & shear forces are more for tube and angular section when compared to pipe section.
- The deflections in the angle section are less compared to the pipe and tube, where the tube has less deflection than the pipe section
- This number of rivets, length of the welding and cost of joints is more in pipe compared to angle and tube
- By increasing the height of the primary support we can reduce the use of the secondary support
- The type of bracings provided is also important in reducing the deflections
- The bracings under the steel plate helps in transferring the loads equally
- The variation in deflection of the material in tube, angle, pipe is due the moment of inertia

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and strength of the respective element

- Finally pipe section is more economical when compared to other two sections

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