Comparative studies of OHE mast used in Indian Railways

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Abstract- Indian Railways contributed in large measure to the socio economic and overall development of the country. Electric traction which was first introduced in India in 1925 is now a regular programmed of Indian Railways. Overhead line is designed on the principle of one or more overhead wires situated over rail tracks, connected to a high electrical potential by connections to feeder stations at regular intervals. An overhead line and structure supported on OHE mast. A traction overhead mast is a simple vertical post embedded in the foundation or rigidly fixed in vertical position to support the overhead equipment with cantilever assembly. There are many challenges associated with these tall and slender structures. In this study parallel flange sections are introduced instead of the traditional rolled section or fabricated section, due to its sectional efficiency and load bearing capacity..

Keywords – OHE mast, parallel flange sections, Indian Railways, RSJ, BFB

I. INTRODUCTION

Electric traction was first introduced in India in 1925. Now the electrification has become a regular programmed of Indian Railways. Therefore there is a great demand for Engineers and Technicians on this highly specialized subject. From Engineering point of view masts are the tall structure with relatively small cross-section. So, there are many challenges for the engineers associated with these tall and slender structures.
Now a day's steel is most desirable material for overhead equipment masts, it may be hot rolled or fabricated steel section. Different types of steel mast which are used in railway are BFB (broad flanged beam), RSJ (rolled steel joist) and K-type, B-type fabricated mast. According to IS 800:1989-2004 these sections are designated as RSJ - WB 200* and BFB designated as SC 150*.

II. DESIGN AND ANALYSIS OF MAST

2.1 Selection of Section –

Here the professionalism of both the client and the designer and their co-operation is vital for the result. Some factors to be considered by the client and the designer are:

1. Mean height of the mast
2. Wind drag on each element
3. Size, weight and disposition of all feeders and cables
4. The degree of security required
5. The available ground and access to the site
6. The geological nature of the site
7. The cost and implications of future maintenance

Any one of these factors can influence the primary choice of the optimum layout of the structure.

2.2. Loads on Masts –

- Wind Load of all masts are based on IS-875-1964. All masts are required to support overhead equipment consisting of catenary wire, contact wire and droppers, and also carry return conductors, earth wire and 25 kv feeder wire.
- Design of mast should be considered on IS 800: 1984 and the load combination should be considered:
  1. Permanent loads only,
  2. Wind load only,
  3. Permanent loads with occasional load and wind blowing perpendicular to track.

To estimate the loads it is necessary to know the extreme range of temperature and wind pressure for which the overhead equipment may be designed.
B-series mast: Battened channel section is used as B-series mast. SC 150,175,200,250,300 section according to IS 1852:1985-2003 all these sections are used as B-series mast. The gusset plates of 6mm and 10mm are used. For 9.5 m length 24 m running metre will be welded. B- Series mast is now very popular in Indian railway. SC 150 known as B-150 is used in normal mast, for balance weight mast and anchoring mast SC 175 (B-175) and SC 200 (B-200) is preferred respectively due to high efficiency.

2.3. Problem found from manufacturer point of view –

From manufacturer point of view RSJ is easy to mould as compared to B-series.

- On manufacturing of B-series mast for 9.5 m length, 24m in running length will be welded.
- So it needs skilled and number of labours.
- The cost of the B-series mast increases 6-7 Rs/t as compare to RSJ.
- Problem from field:
- If it bends in derailments it will be rejected, where as RSJ can be used again and again. So it will not economical.
- RSJ is suitable for normal mast but it is not perfect for curved section with multiple loads.
- The efficient use of material within a steel member requires those structural properties which most influence its load-carrying capacity to be maximized. This, coupled with the need to make connections between members, has led to the majority of structural sections being thin-walled. Moreover, apart from structural steel sections such as universal beams and columns normally comprise a series of flat elements. Simple considerations of minimum material consumption frequently suggest that some plate elements be made extremely thin but limits must be imposed if certain potentially undesirable structural phenomena are to be avoided. The most important in everyday steelwork design is local buckling.
- UC section after it has been tested as a column; considerable distortion of the cross-section is evident with the flanges being deformed out of their original flat shape. The web, on the other hand, appears to be comparatively undeformed. The buckling has therefore been confined to certain plate elements, has not resulted in any overall deformation of the member, and its centroidal axis has not deflected. Local buckling did not affect the load-carrying capacity because the proportions of the web and flange plates are sufficiently compact. The fact that the local buckling appeared in the flanges before the web is due to these elements being in more slender.

III. Results And Discussions

Advantages of parallel flange sections: Parallel flange I-Sections are also used leading to significant economy in steel construction. These sections are divided in 3 categories as per IS: 12778-2004. They are Narrow parallel Flange sections (NPB), Wide Parallel Flange Sections (WPB) and Bearing Pile Sections. The NPB's are mostly used as beam members, WPB's are used for both Beams and Columns and Bearing Pile Sections are used for Compression members. Also PF sections are available as per international standards such as UB, UC, IPE etc. Manufactured as per Indian & International standards, these sections are superior in terms of strength, efficiency, higher axial and bending load bearing capacity, workability and economy vis-à-vis conventional tapered flange beams. These Parallel Flange Beams & Columns enable complex fabrications in high volumes due to inherent functional advantages of these sections. When used under bending load, steel savings between 10-25% are achieved, as beams of lower sectional weight can be used. The load carrying capacity of parallel flange I sections under direct compression are much higher than that of I sections available today. Also connections to the flanges are simpler since no tapered washers etc. are required.

Table-1: Comparison between Exist Section

	r_{xx}(cm)	Lamda	lamda$_{xx}$	D/T	f_{cc} (N/mm^2)	sigma a_c (N/mm^2)	sigma b_{cx} (N/mm^2)	sigma b_{cy} (N/mm^2)

8"x6"	8.48	230.226	195.6921	12.31515	37.20323	20.8	110.4	165
8"x8"	8.89	157.9457	134.2539	16.48	79.04483	41.84	118.8	165
6"x6"	6.45	212.2396	180.4036	12.77311	43.77605	24.6	107	165

Table-2: Design of Parallel Section

	r_{xx}(cm)	Lamda	lamda$_{xx}$	D/T	f_{cc} (N/mm^2)	sigma a_c (N/mm^2)	sigma b_{cx} (N/mm^2)	sigma b_{cy} (N/mm^2)
203x203x46	8.82	158.8694	135.039	18.47273	78.12838	41.24508	107	165
254x254x167	11.9	119.6769	101.7254	9.119874	137.6792	63.8616	140	165
254x254x132	11.6	121.8236	103.5501	10.92095	132.8698	62.28584	137	165
254x254x107	11.3	123.6722	105.1214	13.00976	128.9273	60.96395	139	165
254x254x89	11.2	124.4275	105.7634	15.04624	127.3669	60.43312	127	165
254x254x73	11.1	125.7716	106.9059	17.89437	124.6591	59.50151	123	165

All these sections are safe from design point of view, so trial can be done with these sections.

Table-3: Radius of Gyration about Y-Axis

Section	**r_{yy} (cm)**	**Section**	**r_{yy} (cm)**
152x152x37	3.87	8"x6"	3.54
152x152x30	3.83	200x200	4.305
152x152x23	3.7	8"x8"	5.16
203x203x86	5.34	203x203x71	5.3
203x203x60	5.2	203x203x52	5.18
203x203x46	5.13		

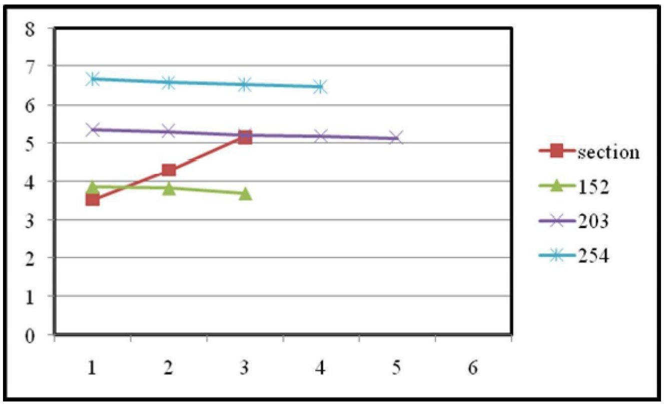

Fig. 1: Radius of Gyration about Y Axis

This graph and table shows that radius of gyration about y-axis of 203x203 UC section is much more than the section used in field. But 152x152 UC sections have lower radius of gyration about y-axis, so here can be use 203x203 UC section.

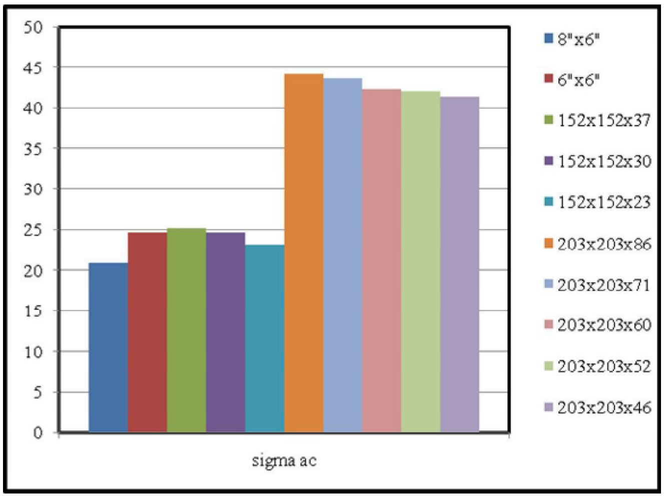

Fig. 2: Axial Stress

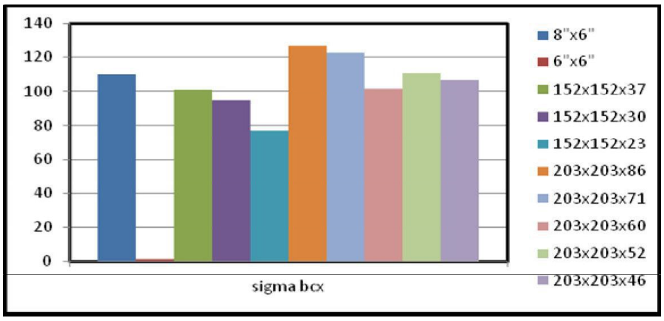

Fig. 3: Bending stress about x axis

These bar charts show that, 203x203 series of UC sections have better bending stress and axial stress than exist section. So, here 203x203 series can be chosen, but, the weight of the section of 203 series is minimum 46, so here suggested section may be taken 203x203x46.

IV. CONCLUSION

In the present study, the researcher mainly focuses to invent a new dimension of mast design/ study. As a result, the above study will give a fruitful contribution in smooth and successful functioning of OHE mast, with an increasing capability at an economic rate. The other suggestive measures has been put forth as follows –

- Initially the electrification system of our country follows French technology of SNCF (Socie'te' Nationals Des Chemins De Fer Francias- Society of National railways of France).
- It was observed from manufacturer's point of view that, to reduce the cost of delivery of the product, it is always needed to reduce the costs of the raw material, as well as the cost of production.
- RSJ (Rolled Steel Joist) mast, a hot rolled steel section, is suitable for normal mast, but it is not perfect for curved section with multiple loads.
- The 203x203x46 may have better efficiency than RSJ and BFB. The weights of the section are also less, so, it may be economical.
- Therefore, 203x203x46 can replaced for normal OHE mast instead of RSJ and B – 150, for better application and durability of the section.

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