Design Optimization of Various Gantry Girder Profile

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Abstract- In this paper investigation is made to suggest the best gantry girder profile by considering various parameters are, gantry span, crane capacity, with & without tandem operation, and various gantry girder profile. For achieving accuracy in vertical bending moment, analysis is carryout for moving load's having span 5m and 7m with crane capacity 30t and 50t using staad pro. For dead load and live load IS 875 -1987 (part 1) and IS 875-1987 (part2) are referred. As per Industrial practice profile are chosen which includes, rolled steel 'I' with rolled steel 'C' at top, symmetrical plate girder 'I', and unsymmetrical plate girder 'I'. The design is performed as per IS 800-1984, all profile result are displayed in the form of bar chart's which is used to suggest best optimum gantry girder profile.

Keywords- Moving load, gantry girder, section profile, optimization.

I. INTRODUCTION

In workshops and factories a very important and useful requirement is to lift and move the heavy loads from one location to the another location of the shop area. Hence it is necessary to provide an overhead travelling crane, for that a platform is made to carry out travelling of crane which is known as Gantry and a long, piece of iron or steel is used to support the whole crane assembly is known as girder. The crane may be a manually (hand) operated overhead traveling crane (M.O.T.) or an electrically operated overhead traveling crane (E.O.T.). A typical arrangement of gantry & crane girder is as shown in Fig1.

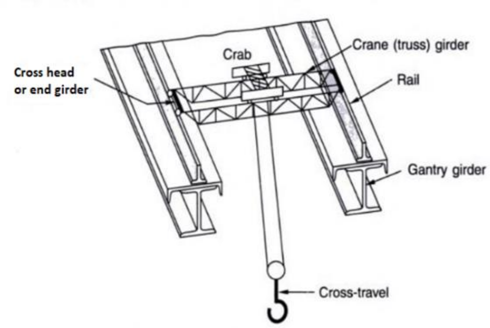


Fig.1 Gantry and Crane Girder Arrangement (reference https://civiljungle.com)

For design of gantry girder the following loads are considered.

1. The reaction from the crane girder, acting vertically downwards
2. The longitudinal thrust, due to the starting or stopping of a crane, acting in the longitudinal direction.
3. The lateral thrust, due to starting/stopping of the crab acting horizontally, normal to the gantry girder.

Gantry girder are designed for maximum vertical and lateral bending moment and shear force. For that it is necessary to suggest the best gantry profile which gives the appropriate result with reducing its weight.

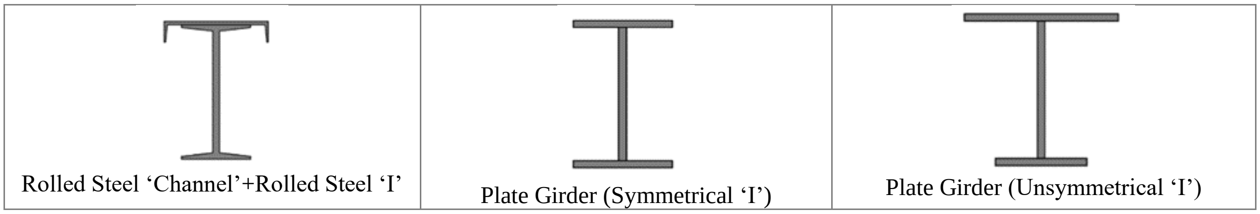
II. PARAMETER'S

In this paper, analysis is carried out considering the parameters are, gantry span, crane capacity, with & without tandem operation, as they are shown in Table1.As we know the profile is selected if they satisfy all design check. For design working stress method is used as per industrial requirement. And for optimization trial and error method is used but, it is very time-Consuming method. To carry out this operation user friendly tool is used.

Table1. In this section parametric study of industrial gantry girder is carried out considering the parameter's are as follows:

Gantry Span (m)	Crane Capacity(KN)	With and Without tandem operation
5m	300	With
	500	
7m	300	Without

Fig.2 Various Gantry Profile



The required initial data for the design of gantry girder are taken as constant for all the parameter's are displayed in Table 2

Table 2 Initial Data

Weight Of Crane (KN)	188
Weight Of Crab (KN)	71
Minimum Hook Approach (m)	1.255
Wheel Base (m)	4.8
Number Of Wheels	8
Weight Of Rail Section (Kg/m)	65
Height Of Rail Section (mm)	130
Grade Of Steel (N/mm^2)	350
Bearing Length (mm)	200

Design Steps:

1. Calculation of maximum wheel load
   - Maximum static wheel load at support of crane will occur when the crane hook is at minimum distance i.e. at minimum hook approach.
   - Add 25% impact allowance (as per IS 875 (Part 2) :1987 clause 6.3)[5]

   Calculation of lateral surge load
   - Total lateral surge load should be considered as 10% of the trolly load plus crane capacity.
2. Calculation of longitudinal breaking load
   - Total longitudinal breaking load should be considered as 5% of static wheel load.
3. Calculation of maximum bending moment & shear force
   - For calculation of maximum bending moment & shear force analysis is carried out using staad pro software.
   - Along with maximum wheel load self weight of girder and weight of rail section should be considered.
4. Selection of gantry profile
   - Section Modulus required is calculated using formula,
   - $B.M_{max}$ x 0.66 fy
   - Check for maximum bending compressive & tensile stresses.
   - Check for shear force.
   - Check for bending compressive stress (due to lateral loading).
   - Check for bending compressive stress (due to longitudinal loading).
   - Check for web crippling.
   - Check for web buckling.
   - Check for deflection.
   - Check for moment of resistance.
5. Optimization of profile by weight using user friendly tool.

III. RESULT & DISCUSSION

After analysis is carried out on staad pro, the generated maximum bending moment (M_{zz}), and maximum shear force (SF) of different gantry spans and crane capacities are tabulated in Table 3.

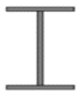
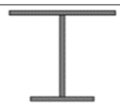
Table 3 Generated bending moments and shear force for different Gantry span and crane capacities.

Gantry Span	Crane Capacity (KN)	Max. B.M. (KN-m)	Max. S.F. (KN)
5m	300	340	330
	500	480	470
7m	300	620	420
	500	870	590

After analysis is carried out using staad pro for moving load the design moments and shear force are obtained. using trial and error method the selected gantry profile with their generated Sectional properties, cross sectional area (C/S), Weight of steel are tabulated in Table 4 and Table 5.

Generated sectional properties include moment of resistance (Mzz), and shear force capacity (SF).

Table 4 Generated sectional properties for crane capacity of 300KN.

Gantry Profile ID	Gantry Span	Md (KN-m)	Mzz (KN-m)	Vd (KN)	SF (KN)	C/S Area (mm2)	Weight of steel (kg/m)
	5m	340	388	330	546	17422	137
P1	7m	620	-	420	-	-	-
	5m	340	515	330	482	13500	106
P2	7m	620	977	420	447	21340	168
	5m	340	472	330	482	13000	102
P3	7m	620	891	420	447	20380	160

From Table 4 it is shows that for 5m span with capacity 300KN obtained design moment is 340KNm and design shear force is 330KN.considering these values for design profile ‘P1’, ‘P2’ and ‘P3’ it gives 388, 515, and 472 KNm moment of resistance respectively and that of shear capacity is 546, 482, and 482 KN respectively.

For 7m span with capacity 300KN obtained design moment is 620KNm and design shear force is 330KN.considering these values for design profile ‘P1’is ‘Not Available’, whereas for ‘P2’,’P3’ it gives 977 and 891KNm respectively and that of shear force is 447 KN which is same for both ‘P2’ and ‘P3’ profile.

Table 5 Generated sectional properties for crane capacity of 500KN

Gantry Profile ID	Gantry Span	Md (KN-m)	Mzz (KN-m)	Vd (KN)	SF (KN)	C/S Area (mm2)	Weight of steel (kg/m)
	5m	480	516	470	606	20568	161
P1	7m	870	-	590	-	-	-
	5m	480	670	470	514	16380	129
P2	7m	870	1390	590	653	27680	217
	5m	480	619	470	487	15580	122
P3	7m	870	1131	590	641	24920	196

From Table 5 it is shows that for 5m span with capacity 500KN obtained design moment is 480KNm and design shear force is 470KN.considering these values for design profile ‘P1’, ‘P2’ and ‘P3’ it gives 516, 670, and 619 KNm moment of resistance respectively and that of shear capacity is 606, 514, and 487KN respectively.

For 7m span with capacity 5000KN obtained design moment is 870KNm and design shear force is 590KN.considering these values for design profile ‘P1’is ‘Not Available’, whereas for ‘P2’,’P3’ it gives 1390 and 1131KNm respectively and that of shear force is 653KN and 641KN ‘P2’ and ‘P3’ profile.

As per design point of view the profile is safe if it satisfied all design check, but as we know if weight of steel increases, the overall cost of project is also increases. Hence, as per role of structural engineer it is necessary to suggest the best profile which satisfy all design check with economy.

Fig 3. To Fig 6 show's the bar chart's for B.M., S.F., and Weight of steel per meter. It represents that on vertical axis it shows the values of B.M. whereas horizontal axis shows the gantry profile. Md and Vd are the design moment and shear force.

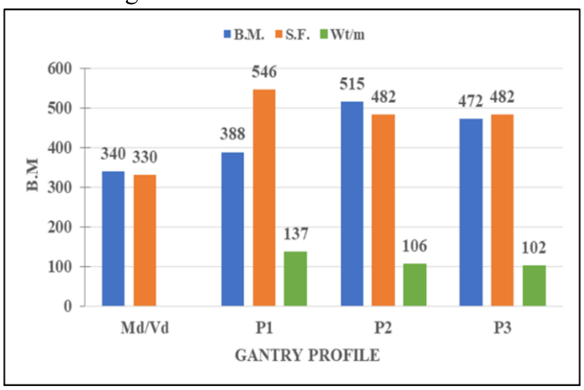


Fig.3 B.M, S.F, and required weight of steel for crane capacity 300 KN (30t) with span 5m.

The % increase value of moment of resistance are 14%, 51%, & 39%, for profile ‘P1’ to ‘P3’ respectively. As it clear that profile ‘P3’ has minimum weight with satisfied moment of resistance 472 KNm and Shear carrying capacity 482KN.

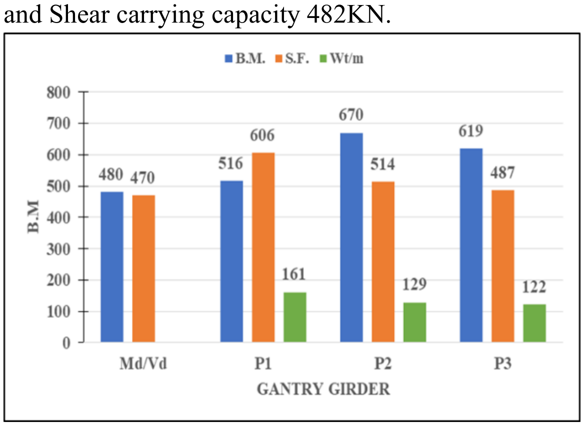


Fig.4 B.M, S.F, and required weight of steel for crane capacity 500 KN (50t) with span 5m.

The % increase value of moment of resistance are 8%, 40%, & 29%, for profile ‘P1’ to ‘P3’ respectively. As it clear that profile ‘P3’ has minimum weight with satisfied moment of resistance 619 KNm and Shear carrying capacity 487KN.

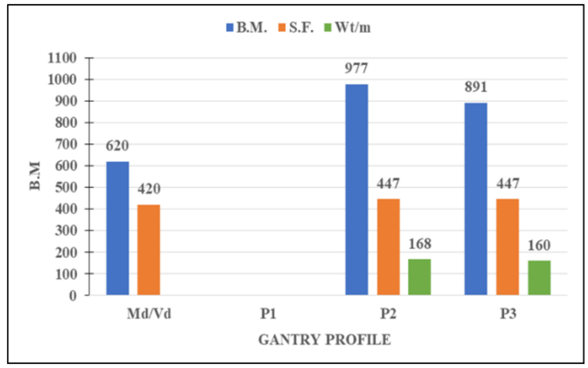


Fig.5 B.M, S.F, and required weight of steel for crane capacity 300 KN (30t) with span 7m

The % increase value of moment of resistance are 58%, & 44% for profile ‘P2’ and ‘P3’ respectively. Whereas profile ‘P1’ is Not Available. As it clear that profile ‘P3’ has minimum weight with satisfied moment of resistance 891KNm and Shear carrying capacity 447KN.

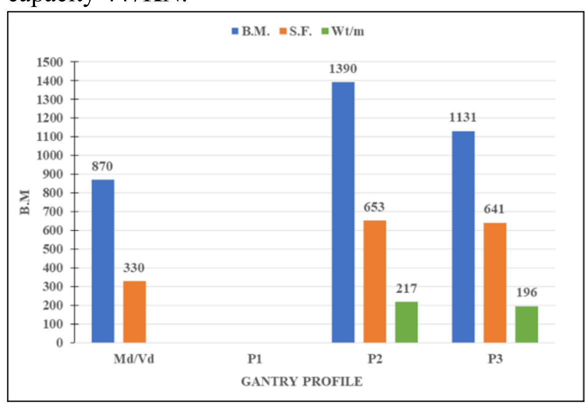


Fig.6 B.M, S.F, and required weight of steel for crane capacity 500 KN (50t) with span 7m

The % increase value of moment of resistance are 60%, & 30% for profile ‘P2’ and ‘P3’ respectively. Whereas profile ‘P1’ is Not Available. As it clear that profile ‘P3’ has minimum weight with satisfied moment of resistance 1131KNm and Shear carrying capacity 641KN.

IV. DESIGN METHODOLOGY

In this project considering industrial practice, various combination of rolled steel and fabricated profile are selected.

In profile ‘P1’ combination of rolled steel ‘I’ with rolled steel ‘Channel’ are taken, it gives satisfied result for span 5m with capacity 300 KN & 500 KN. But due to its limited depth and availability unnecessarily it is required to provide, hence it not economical section.

In profile ‘P2’ symmetrical fabricated ‘I’ are taken, it gives satisfied result for both span and crane capacities. But due to symmetrical profile there is not ultimate use of bottom flange, hence due to unnecessary required bottom flange increases the weight of profile.

In profile ‘P3’ unsymmetrical plate girder ‘I’ are taken, by providing bigger compression flange than tension flange found to be more economical profile than all other profile for both span and crane capacities with satisfied results.

V. CONCLUSIONS

1. For gantry span 5m with crane capacity 30t and 50t and also for span 7m with crane capacity 30t and 50t, profile ‘P2’ that is ‘Symmetrical Plate Girder’ gives maximum moment of resistance i.e. between the range of 40% to 60% than required. To satisfy the bending compressive stress due to lateral loading if we increase the compression flange, then due to symmetry unnecessarily tension flange is required, hence ultimately weight of profile is increases, due to this is not economical gantry profile.
2. By providing profile ‘P3’ that is ‘Unsymmetrical Plate Girder’, i.e. bigger compression flange than tension flange to satisfy the lateral bending check. For both span and crane capacities it gives the moment of resistance in the range of 30% to 40% with minimum weight of steel compared to other profile.
3. As moment of resistance is directly proportional to moment of inertia and inversely proportional to maximum distance of neutral axis from outermost edge of plate, hence required moment of resistance satisfied by providing ‘Unsymmetrical Plate Girder’ with minimum cross section area.
4. For crane capacity 300KN (30t), span 5m ‘P1’ gives 34.31% and that of ‘P2’ gives 3.92% more weight of steel compared to ‘P3’, span 7m ‘P2’ gives 5%, and for capacity 500KN (50t), span 3m ‘P1’ gives 31.96%, ‘P2’ shows 5.74% and for span 7m ‘P2’ shows 10.71% more weight of steel compared to ‘P3’. Hence optimum gantry profile is “Unsymmetrical Plate Girder.”

REFERENCE

[1] S.Dutta, D.Chatterjee 2019.Value Engineering Study of Various Gantry Girder Profile. International Journal of Research in Advent Technology, 8(6):2321-9637.

[2] Garg,A. 2016. Gantry girders in India. International Journal of Civil, Mechanical and Energy Science, 2(6): 2455-5304.Iyappan, S.Kumar, P.V. Sarathy, R.V. Tamilvanan, G. Venkatesh, A. and Vignesh,S. 2016. Design of an overhead plate gantry girder. International Journal of Development Research, 6(5): 7821-7823.

[3] IS 800:1984, Code of practice for general construction in steel, Bureau of Indian Standards, New Delhi.

[4] IS 875(part I):2003, Code of practice for design loads (other than earthquake) for buildings and structures, Bureau of Indian Standards, New Delhi.

[5] IS 875(part II):2010, Code of practice for design loads (other than earthquake) for buildings and structures, Bureau of Indian Standards, New Delhi.