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Pragmatic Methodology for Increasing the Volumetric Capacity of the Freight Cars on the Indian Railways

A Stepped Procedural Methodological Approach to Meet Accelarated Freight Transport Demands

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***Abstract*- The superstructure of a Railway Wagon has three major components to focus upon, namely Underframe, Side Body and End Body. The underframe has certain associated key components such as the draft gear and coupler while the wagon body is designed to bear with high static and dynamic loads. If the load increases both the Wagon Body and the Underframe should suffice for the critical loading conditions with standard Margin of Safety. However the present designs of wagons and the supporting infrastructure is not apposite to the needs of accelerated demands for transport. The required designs have not been implemented even when the demands for freight transport are increasing at an enormous rate.**

Keywords—Margin of Safety, CBC Coupler, Wagon Height, Maximum Moving Dimensions, Track Load Density, Roll on Curve, Dedictaed Freight Corridor.

I. INTRODUCTION

This paper elaborates a practical approach to handle ever increasing Freight Transport demands after rigorous research and testing of prior art. It provides a method and design for developing an international standard load carrying freight wagon car in India. The paper was thought and formulated on the basis of three major reasons: (1) Freight trains account for two-thirds of revenues of IR, though has seen miniscule improvements in payload-tare ratio for several years now (2) According to a study by FOIS the requirements for Freight is expected to grow from existing 1604Billion Tonnes Kilometers to 16653 BTKM by 2040 assuming a level 1 progress pattern(@8.27 % increase annually) in the cement and manufacturing sector, and (3) Ongoing Project- Dedicated Freight Corridor ongoing since Aug,2011 addressing the urgency of improving Payload to Tare Ratio and in the meanwhile reducing the restrictions of MMD and Track Load Density. Highlighting the need the IR has already issued global Tenders for increasing the payload to 32.5 ton axle loads as per the August Annual Report of 2012 wherein it states **"Higher load Wagons with pay to tare comparable internationally"** are in urgent demand. This change is altogether not possible until the DFC is built to function, but we can run the wagons with about 30 tons on the existing Tracks that are there in the IR. Within this limit the **Track Load Density** can be handled easily. So with this a step procedure for the increase is suggested where-in a kind of modular design could be formulated which could be adapted to the high axle loads of 32.5 tons too.

II. BACKGROUND

A. The need for the Payload-Tare Ratio increase

"Transport Investment is a response to emerging demands, but it is also an Economic growth driver in itself"- NTDPC Report.Vol1. As evident the requirements of Freight Carrying Capacity increase is necessary to keep up with the transport demands of the all sectors, be it energy sectors, Manufacturing sectors or any else. This should provide growth and the impetus of improving the P-T ratio in an accelerated manner.

B. The proposed Plan for Implementation

As mentioned earlier, the DFC project is still in incubation for 3 years now. But the transport demands have accelerated rather than remaining the same. It is true that the current tracks and infrastructure may not provide for higher load carrying Wagons, but then there is a way of designing a Wagon that could be modified when the advent of DFC's becomes a reality. These wagons could be designed for the maximum loads that present resources would allow apart from being adaptable for changes throughout the stages of development in the infrastructure. So I propose to increase the load carrying capacity in stages from 22.9>25>27.5>30 and finally 32.5 tons apart from developing a novel design for a similar Wagon.

III. SUMMARY

Designing a Railway Wagon involves a magnanimous effort. Apart from the need to address the regulations of a particular code you follow for it, you also have to smartly decide which code to follow. Only then it would fetch you feasible results for the scenario at hand.

So in designing a Wagon for the higher loads of 30 ton (at the least) involves even more adherence to the safety standards. A detailed analysis of the system designed was done according to the AAR standards followed and also by a crude analysis and testing procedure divided into 5 sections.

After detailed inspections and iterations and several iterations the Proposed Wagon Design did away with the extra added weight of the stringer and crossbar which kept the side body intact. Apart from that several other related components were removed. In fact the Underframe was merged with the Wagon body and so many channels were also done away with. To prevent excessive deflection of the side body of the wagon, the Side and End Bodies were Die-Punched in the appropriate space with existing capabilities of the machines available for punching. The punch direction was opposite to the direction of deflection expected and it proved to be sufficient for the coupler direction floor plates but not for the side body joining regions. The adage technique of dividing the forces throughout the underframe could not be applied in this case because of the novel Design of the underframe. Therefore to simulate a realistic scenario while doing the analysis a uniformly distributed load was assumed for the static condition depending upon the weight of the material (assumed coal with density 1016kg/m3) above it. Smartly calculating the analysis conditions involved the following methodology:

Weight enclosed above a section ∞ Volume enclosed above it ∞ The cross-sectional area of the section in lateral directions (Neglecting the punches).Punches are actually uniform throughout the wagon so if the payload is divided in terms of cross-sectional area it is a viable alternative. After this the breakup of load is applied in an assumed UDL manner. The TDL will come out to Gross Load/Length of Wagon over Couplers or (30*4/12=10(approx)) which is well below upper limit of 12. The axle loads of the freight wagon mainly affect the bridge in two ways: local load and integral load. The local structure of the bridge shall be directly affected by the class of the axle load, and the integral load shall also take the load density into consideration beside the axle load. Before listing down the results and analysis I will list down the following parameters that were focused upon:

- Height of the Wagon- It was kept within the MMD as per the DFC specifications after August, 2012.
- Floor Height of the Wagon- Suggested to be modified to 1050 from the existing value of 1273 meters.
- Width of the Wagon –Kept within the existing dimensions but a wider corridor is proposed in the DFC.
- Obstructions along the width and the height.
- Effect of bogie Movement containing a whole lot of sub-topics: Bouncing, Lateral Swing, Roll, Cant Deficiency, etc.

A. Abbreviations and Acronyms

MMD-Maximum Moving Dimensions, TLD-Track Load Density, DFC-Dedicated Freight Corridor, UDL-Uniformly Distributed Load, AAR-American Association of Railroad Standards, RDSO- Railway Design and Standards Organization, Mpa- Mega Pascal (1*10^6 $kgm^{-1}sec^{-2}$) .

B. Units

- Volume will be mentioned in Kilogram per cubic meter unless explicitly mentioned.
- Weight will be mentioned in metric tonnes or in Kilograms.
- Mostly SI units will be used for derived quantities or properties.

C. Equations and Calculations

- A roll permissibility of 3 degree is allowed
- Cant Deficiency was calculated and under the conditions of loading and cant the wagon could reach maximum speeds of 98km/hr.

Property	RDSO P1	RDSO P2	Proposal Estimated
Length over Coupler	10.96 m	10.778 m	12 m
Volume	61.5 m3	69.72 m3	94 m3
Structure Weight	8.78 tonnes	8.48 tonnes	12.96 tonnes
Air Brake	0.50 tonnes	0.78 tonnes	0.70 tonnes
Coupler Weight	1.32 tonnes	1.04 tonnes	1.04 tonnes
Bogie Weight	10.8 tonnes	9.70 tonnes	10.30 tonnes
Total Tare	21 tonnes	20 tonnes	25 tonnes
Payload	70.6 tonnes	80 tonnes	105 tonnes
Axle Load	22.9 tonnes	25 tonnes	32.5 tonnes
Pay to Tare	3.36	4	4.20
Wagons In Rake	59	59	53
Rake Throughput	4165.4 tonnes	4720 tonnes	**5565 tonnes**
Gross Trailing Load	5404	5900	6890
Speed Limit	100 km/hr	No Design	90 km/hr

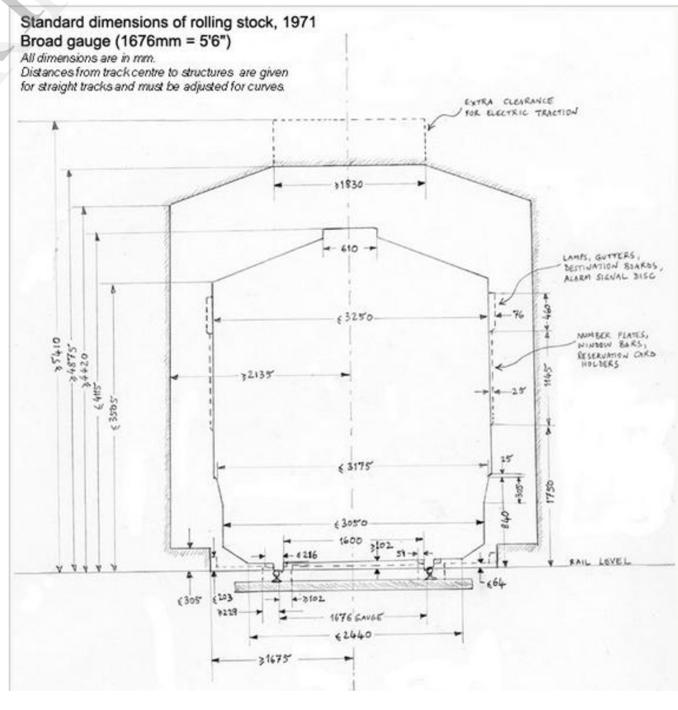


Figure 1: The standard Rolling Stock MMD

- This will be an 18% increase in Rake throughput.
- The gross volume came out to be 94.004 m3 which the wagon could be laden with.
- A volume of 2.26569 m3 was subtracted before calculating gross volume for the punches (2.20 m3), and the inside strengthening piped supports, etc (0.06569 m3)

- Even with the least bulk density of coal which is around 900 kg/m3, the load that can be accommodated in this volume itself will be around 84.9 tonnes.
- Assuming a top heap load of at least 10 tonnes that is to be added as per the wagon design manual of IR, the design can hence accommodate even more weight; up to 96 tonnes as payload.
- The following image shows the breakup of loading conditions in a single case testing with 35% overload :

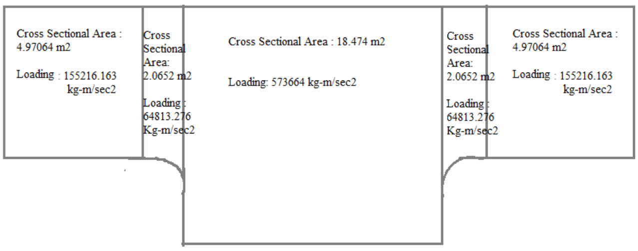


Figure 2 : Showing the loading diagram for 35% overload test (A single case)

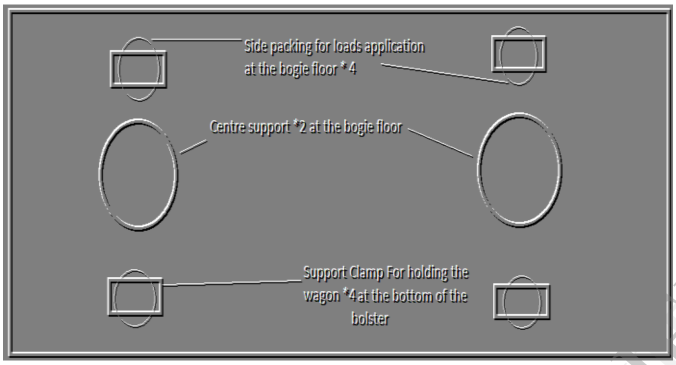


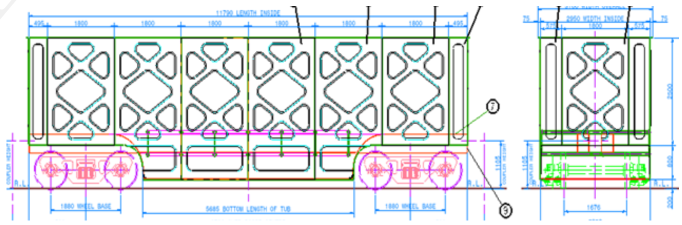
Figure 3: The self weight application regions at Centre and Side Plates

- The five cases analyzed were as follows:
  a. Empty Self weight (85% at Centre Plates and 15% at the Side Plates).
  b. Payload in UDL Fashion +Empty Self Weight as above.
  c. 30% Overload + Empty Self Weight in the above formats.
  d. Squeeze Test with 250 tonnes crushing force.
  e. Squeeze Test with 453.6 tonnes crushing force.
- Apart from these separate components were tested as per the AAR to ensure enhanced safety as shown below:

MEMBER	CRITICAL LOADING	MARGIN OF SAFETY
Side Seal and reinforcement	50% live load from door post to End + Dead Load + Lift Truck in Door way.	+ .52
Crosstie	Dead Load + 50% Live Load Over 10 ft. at Center of truck + Impact Load.	+ .23
Cross Bearer	Dead Load + 75% Live Load over 24' at Center of Car	+ .07
Stringer	Lift truck Wheel Load	+ .61
Bolster	Dead Load + Live Load + Compressive End Load.	+ .10
Side Post	Car Loaded to eves with 100% Live Load.	+ .25
Center Sill	Dead Load + 25% Live Load forward of Bolster + Impact Load	+ .22
Roof	15lb/ft2 distributed load + 300 lbs concentrated load	+ .20
Front Draft Lugs	3, 50,000 Lbs Draft Load.	+ 1.06
Back Stop Sticker	1,000,000 lbs compressive End load 50,000 lbs vertical load on	+ 1.14 + .10

Note: Certain Components mentioned above are not present in the new design so either a new testing procedure is done or the test is left out for further consideration

Figure 4: Incomplete Diagram of Wagon Body



D. Analysis and Results :

The Material for Analysis was considered to be Mild Steel Grade E 450 with 60% of Yield Stress i.e. around 290Mpa.

- The analysis showed success in most of the areas but the tippling conditions still remain assumed to be successful.
- There are regions of the tub showing signs of failure if not strengthened appropriately.
- The gondola Type wagon will have to be Made and tested as a prototype for accurate results.
- After several tests and analysis with several modifications in failure prone areas the maximum tensile stress has been reduced to 290Mpa (very near to acceptable 285 Mpa)

- Apart from this the Crushing Test is a cause of concern as compressing stresses are as high as 600 Mpa symmetrically in the top Flanges against acceptable values of 450 Mpa.

- Some Images are shown below of the last iterative design thought of:

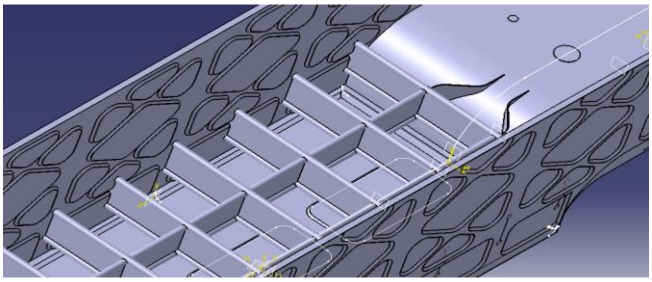


Figure 5 View from Inside

Figure 6: The bottom view with modified underframe

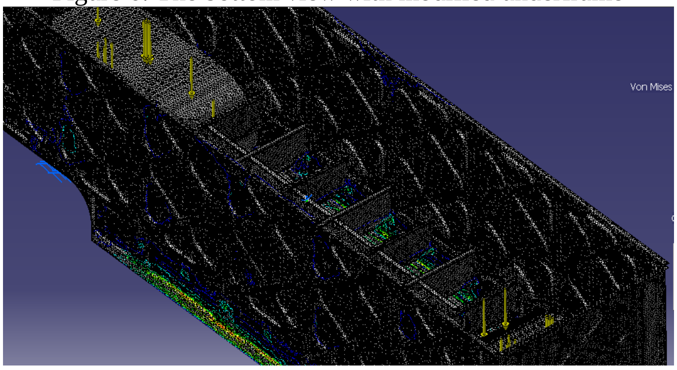


Figure 7: Last Analysis Showing Failure Prone Areas in Overloaded Testing

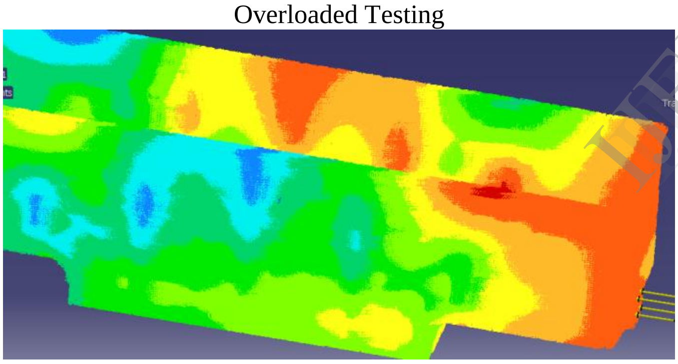


Figure 8: Portrayal results of 453.6 tonnes squeeze test

IV. USAGE OF THE PROPOSED DESIGN

The design is supposed to be a boon for the future of wagon design in India. The future demands for Freight Transport will be easily met if such projects are paid heed to and utilized soon enough. The application of the Project is well explained and the results of such a design with such capabilities can be understood even y a newbie. It is hence imperative that such a design is tested and improved soon enough to start production before the DFC is finalized and put to use.

ACKNOWLEDGMENT

The advent of such transportation abilities will revolutionize the Nation towards development. It will have gigantic indirect effects on boosting of the manufacturing sector within the country. Soon the country will see sufficient export capabilities on the other hand parting with the problem of import requirements. An increased hauling capacity is not an alien improvement and has been a prevalent issue. Therefore such a novel design and testing will pave the way for prompt testing and implementation at the expertise of RDSO, India.

REFERENCES

There has been a lot of referenced material throughout this project. Most of the sources are verified through research themselves. The reports and web pages not mentioned below would include the overwhelming guidance of the website of IRFCA and FOIS (https://www.irfca.org/faq and https://www.fois.indianrail.gov.in). Apart from this the support of Indian Railway Technical Handbook is also to be contributing to this project. The expertise and guidance of Sir Ashutosh Kumar Banerjee has been the most promising support throughout the project and has helped in maintaining a level of quality in whatever has been done in this project. His expertise and wide ranged experience with the Indian Railways was crucial to the fact verification and justification throughout the project.

[1] Yi-Qing Ni Xiao-Wei-Xe, "Proceedings of the 1st International Workshop on High-Speed and Intercity Railways," in press.
[2] Colin Cole, Longitudnal Train Dynamics, Chap 09. iwnicki, in press.
[3] M. Naveen, K. Jagadeshwar, M. Sai Satish Chandra, T. P. S. Avanish, "Optimisation of Rolling Stock," E-ISSN 0976-3945 ,in press .
[4] Report of the National Transport Development Policy Committee,NTDPC_Vol01,in press .
[5] Annual Report, RDSO , 2010-2011" , in press.
[6] Lennert Senger," D2.2 "Data Collection Report" ,July 2013, in press.
[7] RDSO Training Wagon Report Scribd/Acc No : 68112358,in press.
[8] Design and Maintenance of Railway Freight Wagons,RDSO,Elsevier,in press.