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Load Test on Post Tensioned Pre-Stressed Concrete Gantry Supporting Girder

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Abstract: Load testing is one of the functional tests to validate if it can be used with confidence. It is the process of applying loads on a system and measuring certain useful parameters. It is carried out to determine the behavior of the system under service load conditions. It helps identify the maximum loads that the structural element can withstand without much deformation. It will also help finding out any deficiencies to determine which part of the system causes failures. The load-deflection behavior of the Gantry supporting girder has been studied by carrying out the load test after simulating the actual field conditions. The deflections under different load conditions have been noted down. Maximum deflections at mid span due to live loads were noted down and the average hogging in the PSC gantry girder was also noted down. The vertical displacement of girders at mid span due to imposed load was compared with the hogging [upward deflection] of the beam. Also, the recovery at mid span was observed on removal of the test load. Finally, the beam was checked for any cracks to find out if the beam was capable of carrying the intended live loads.

Keywords: *Load test, Gantry girder, Pre-stressed concrete, Deflection, Recovery, Single point loading*

Introduction:

Pre-Stressed Concrete (PSC) girders are being used for long span bridges, flyovers, etc., nowadays, since they posses certain properties which cannot be expected in those made of ordinary reinforced concrete. Though steel girders can be conveniently used with ease in such cases, the advantages of using PSC girders always outweigh those of steel structures. Moreover, maintenance cost is almost nothing even as that for the steel girders is very high and to be incurred periodically. But, in PSC elements, one has to be very careful during stressing operations to ensure proper elongation or stress applied. Any mistake in the stressing operations may lead to failures. Hence, it is always advisable to check the load carrying capacity of the girder cast, before erection at the intended locations. The beam should be randomly selected and tested for the design loads. The deflection at mid span should be noted and compared with that of the theoretical value to find out if the beam can be utilized effectively.

Review of Literature:

Experimental investigations by Abeles, P.W., [1] have shown that micro cracks develop at a tensile stress of about 3 N/mm^2 which are invisible to the naked eye. On further loadings, cracks are first visible at flexural tensile stresses between 3.5 and 7 N/mm^2, the higher values generally correspond to beams with well bonded steel distributed close to the tensile face, as in the case of pre-tensioned. The load deflection curve is approximately linear up to the stage of visible cracking and beyond this stage, the deflections increase at a faster rate due to the reduced stiffness of the beam. In the post cracking stage, the behavior of the beam is similar to that of reinforced concrete members. The deflection of cracked structural concrete members may be estimated by the unilinear method though it results in gross over estimation of deflections, particularly in the working load range and under estimate for higher load ranges. Experimental investigations have shown that a closer approximation to the actual load deflection behavior is possible by assuming bilinear movement. The instantaneous deflection in the post-cracking stage is obtained as the sum of the deflection up to the cracking load based on gross section and beyond the cracking load considering the cracked section.

Mike lau, et.al., [2] in their load test on pre-stressed concrete girders, after examining all the test measurements in terms of strains and deflections, concluded that the observed higher load carrying capacities were a result of load spreading and the ability of sections adjacent to the loaded sections to develop plastic deformation prior to the collapse of the loaded structural elements. While this observed phenomenon is not unique to the monotonic single point loading, the same higher loading capacity cannot be expected to be realized under the real bridge loadings which are multiple point and repetitive.

Indian Road Congress [3], as per clause 6.6.2 ,for girder bridges, the load for rating should be taken as the least of (i) the load causing a deflection of 1/1500 of the span in any of the main girders for simply supported spans (or) for cantilever span, the load causing a deflection of 1/800 of the cantilever span in any of the main girders,(ii) the load causing tension cracks of more than 0.3mm in any of the girders for normal cases and 0.2mm for structures exposed to very severe and adverse conditions,(iii) the load causing appearance of visible diagonal cracks of width more than 0.3mm for normal cases and 0.2mm for structures exposed to very severe and adverse conditions or opening / widening of existing cracks close to the supports in concrete girders, (iv) the load at which recovery of deflection on removal of load is not less than 80% for RCC structures and 90% for Pre-stressed concrete girders.

Indian Road Congress [4], vide clause 5.2 ,for bridges designed for IRC standard loadings, criterion for load testing of PSC beams, after retention of test load for 24 hours, the minimum recovery of deflection after removal of test load should be not less than 85%. A general acceptance criterion for the behavior of a structure under test load is that it shall not show "visible evidence of failure" which include appearance of cracks of width more than 0.3mm, spalling or deflections which are excessive and incompatible with safety requirements.

Details of Gantry Supporting Girders:
Gantry supporting girders of grade M40 are used for carrying the moving gantry crane passing over the rails fixed atop them. They are made of either steel or pre-stressed concrete and used in Industries / hydraulic structures. The Gantry girder under study has a length of 17.96m, depth of 1100mm and the width of top and bottom flange at mid span are 1750mm and 450mm respectively even as those at ends are 1300mm and 600mm as shown in Figure1.

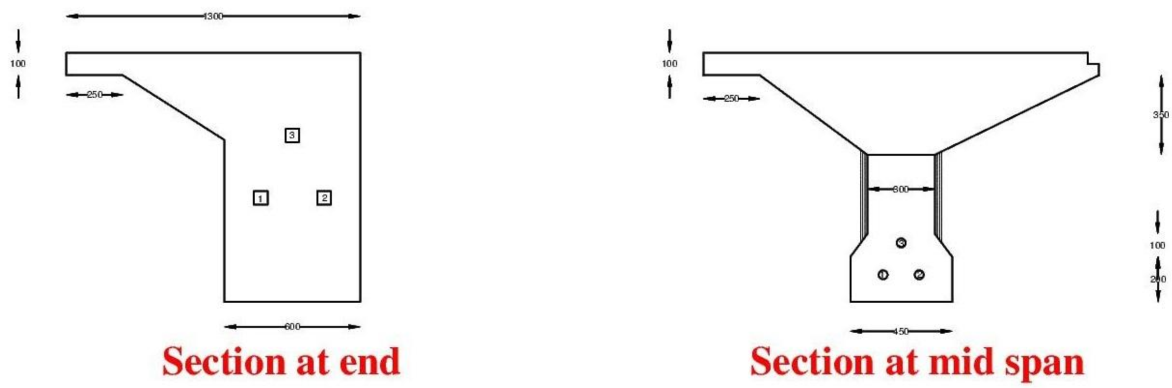

***Figure 1** : Sectional Details of Gantry girder at Ends and at Mid span*

Salient Points in Stressing Operation

- Cable No.1 & 2 was in the first stage while Cable No.3 was in the second stage.
- First stage stressing was done after 12 days or after concrete attained a cube crushing strength of 33 N/sq.mm whichever was later.
- Second stage stressing was done after 18 days or after concrete reached a cube crushing strength of 37 N/sq.mm whichever was later.
- All cables have 9 strands and are of 12 T 13 pre-stressing system with 66mm ID sheathing and are uncoated stress relieved low relaxation seven–ply strands conforming to IS:14268 – 1995.
- Reinforcements were locally adjusted wherever they interfered with sheathing.
- Stressing was done from both ends simultaneously.
- Jack pressures were derived by considering ram area.

Jack type: ISMAL 1800 MG.

Assumed parameters:
Area of strand = 98.7 sq. mm
Jack efficiency = 95%
Young's modulus of
pre-stressing steel = 1.95×10^5 N/sq.mm.
For any variation in parameters, expected elongation to be computed as

$$\frac{\text{Theoretical elongation} \times 98.7 \times 1.95\times10^5 \text{ (sq.mm)}}{\text{Actual area of strand} \times \text{Actual modulus of elasticity (N/sq.mm)}}$$

Any cable profile consists of straight inclined portion behind the anchorage and then vertical deviation through a second degree parabola. The start of the parabola is the point on the cable nearer to the support and the end point nearer to mid span. All horizontal deviations are by means of a pair of reverse curves of second degree parabola.
The jack force was corrected for the variation in jack efficiency as shown:

$$\text{Jack force} = \frac{\text{Jack force designed} \times 0.95}{\text{New jack efficiency}}$$

The jack pressure & elongation should tally with each other to within 5% after correction for actual jack efficiency, area of strand and modulus of elasticity of H.T.S. If the elongations are obtained earlier than at the desired jack pressure, then continue stressing further till the desired jack pressure or a maximum elongation of 5% whichever is earlier, is obtained. If the jack pressure is reached earlier, then the stressing shall be continued further to a maximum of 5% extra jack pressure or attaining the required elongation whichever is earlier. If the designed jack pressure / elongation are not obtained after 5% increase in elongation / jack pressure, it has to be redesigned.

- The girders shall be lifted from a point not more than 0.5m from centre line of bearings with supports right below the web.
- The holes in webs used for maintaining web thickness in shuttering were plugged with grouting.

Bending moment at mid span on the PSC gantry girder due to Class A loading including impact factor has been calculated as 778.4KNm and taken as 780KNm (approx.) and the Load / unit length (w) has been arrived at as 20.9KN/m.

Therefore, load for entire length of girder is calculated as 375.78 KN.
For two girders, 2x375.78 = 751.56 KN (≈ 75.15 Tonnes)

Table I: *Details of loading on platform*

Loading percentage	30%	20%	20%	10%	10%	10%	100% (Total load)
Metric Ton	22.545	15.03	15.03	7.515	7.515	7.515	75.15
No. of Bags*	752	501	501	251	251	251	2507

*Average weight of sand bag is 30 kg each (as confirmed at site)

i) Load due to superimposed load was calculated as 16.18Tonnes and equivalent to that, the sand bags were uniformly placed on the platform. Self weight of platform was also calculated and included in the same.

ii) The deflections on girder 1 and 2 at mid span due to the superimposed dead load were found to be 3.33mm and 1.67mm respectively.

Load Test Arrangement: The test set up for conducting load test on Gantry girders, which is self explanatory, is shown in Figure 2

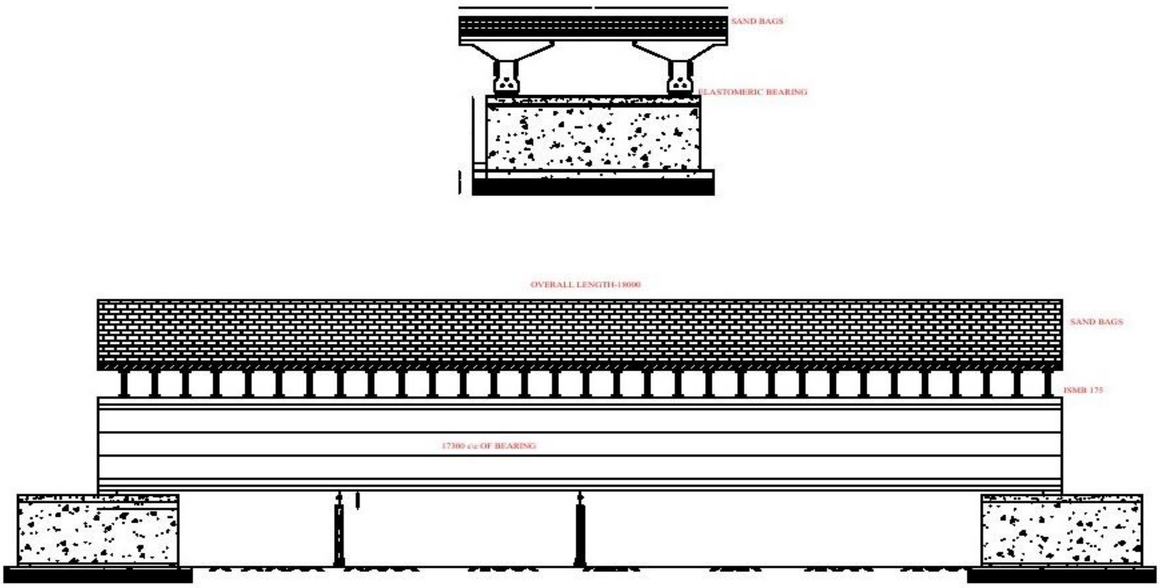

***Figure 2** : Test set up for Load test*

Prior to commencement of load test, the following arrangements were made at site:

- Pedestals were constructed and cribs were erected on hard base at girders' support region, quarter spans and mid spans for placing of deflectometers.
- The position of the bearing pads was marked on the pedestals and bearings were placed at appropriate locations.
- The PSC gantry girder was placed over the bearing pads on the pedestals.
- Similarly, the second PSC gantry girder was also placed on the pedestals.
- ISMB, ISMC & rails sections were placed spanning across the PSC girders and MS sheets were placed above the steel sections in such a way that the whole area is covered.
- The self weight of steel sections and MS sheets were pre-weighed and recorded.
- Lighting arrangements were made while conducting load test. The loading materials viz., sand bags were kept ready for application of test load.
- A platform balance was made available at site for confirmation of weight of loading materials and

required laborers were deployed at site for loading & unloading.

Test Methodology Adopted

The following are the stepwise procedure adopted for conducting load test as per standard practice:

- The girders were examined thoroughly for any cracks or imperfections. Deflectometers were fixed at mid span, quarter span and also near supports and ensured that the plunger of deflectometers were having a firm contact with the bottom of girder.
- The super imposed load component (inclusive of self weight of ISMB, Rails, ISMC and MS sheets) on the girder was calculated and the same was imposed on the girder through sand bags.
- The initial readings in the deflectometers were recorded and readings in the deflectometers were noted for every one hour for 24 hours for understanding the behavior of the girder due to temperature.
- The initial readings of the deflectometers, time and temperature were recorded. First increment of 30% of test load was applied uniformly over the entire area of platform.
- Once the readings got stabilized, the readings in the deflectometers, time and temperature were recorded.
- Second incremental loading of 20% of test load was imposed on the girder and deflectometer readings, time and temperature were recorded on similar lines.
- Similarly, further incremental loadings (i.e., 70% 80%, 90% & 100% of Total load) were imposed on the girder.
- At each incremental loading, deflectometer readings, respective time and temperature were recorded. At the end of every incremental loading, observations were made for any imperfections in the PSC gantry girder, or extending / widening of existing cracks or appearance of fresh cracks etc., (if any).
- After application of full test load on the girder, the instantaneous deflection was recorded.
- The deflection was monitored for 24 hours under sustained load by noting down the readings in deflectometers at every 1 hour interval.
- Simultaneously, time and temperature were also recorded.
- At the end of 24 hours after loading, the deflectometer readings, time and temperature were recorded and the maximum deflection was worked out after considering the support settlement.
- The imposed test load was released by removing the load from the platform in the same decremental manner adopted while loading.
- Similarly, corresponding deflectometer readings, temperature and time were recorded at the end of each decremental loading.
- After removal of entire test load and stabilization of readings, instantaneous recovery of deflection was recorded.
- Recovery of deflection was also measured for the next 24 hours. Simultaneously, time and temperature were also recorded during that period at every 1 hour.
- Recovery at the end of 24 hours of removal of test load was worked out considering permanent settlement of pedestals.

Temperature Effect: The temperature variation during load test was recorded for applying necessary correction for deflection and deflection recovery. It was found that the temperature variation was quite small and did not have a major effect on the deflection. Hence, the temperature correction was not considered for deflection calculation.

Acceptance Criteria: Minimum percentage recovery of deflection as per clause 5.2 of IRC SP 51 – 1999 at 24 hours after removal of test load is 85%.

Maximum deflection is 1/1500 of span which works out to 11.55mm from the true horizontal level of girder as per clause 6.6.2 of IRC SP 37-1991.

Results of Test: Cracks of limited width can be accepted under occasional over loads. Knowledge of the load deformation characteristics of cracked members is very much essential to comply with the limit state of deflection. If the beam is sufficiently loaded, tensile stresses will develop on the soffit and when this stress exceeds, the tensile strength of concrete, cracks are likely to develop in the member.

Maximum deflection at mid span due to the live load is 11.71mm and 8.55mm in girder 1 and girder 2 respectively. The average hogging (upward deflection) in the PSC gantry girder at mid span was found to be 29mm in both girders. Since the vertical displacement of girders at mid span due to imposed test load did not exceed the hogging of 29mm, the tested girders are considered safe for the intended live loads. The observed deflection was well within the hogging and above all, a minimum of 90% deflection recovery at mid span was observed on removal of test load in both the PSC girders.

Concluding Remarks: The results of load test indicated that the PSC gantry girders tested are found to have performed satisfactorily under test loads.

Further, no cracks or permanent deformations / distresses were observed in the girders during and after testing.

References:

[1] Abeles, P.W., Introduction to Pre-stressed Concrete Vol. II, Concrete Publications Ltd., London 1966, pp. 542-554.
[2] Mike Lau, Asnee Pochanart, Ruth Eden –Adjusting to New Realities, Annual Conference of the Transportation Association of Canada.
[3] Indian Road Congress (IRC) SP 37-1991.
[4] Indian Road Congress (IRC) SP 51-1999.