Failure Analysis and Prevention Strategies For I-PSC Girders During Stressing

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Abstract

This study focuses on identifying the primary causes of PSC I-girder failures during the stressing process and proposes preventive measures to mitigate such occurrences. Key factors contributing to failures include inadequate support arrangements beneath girder soffits, insufficient bracing, lack of interconnections between adjacent girders, and improper supervision during critical phases of construction. Material deficiencies, such as substandard anchor cones, wedges, and high-tensile wires, along with construction errors like misalignment of tendon profiles and over-tensioning, further exacerbate the risk of structural failures. The anchorage zone is particularly susceptible to failures due to insufficient reinforcement detailing, inadequate end blocks, and poor concrete quality, leading to cracking or spalling during the transfer of prestressing forces. Additionally, thermal and shrinkage effects, especially during early-age curing, can induce residual tensile stresses, resulting in cracking and compromising the girder's integrity. Ten I-PSC girders were analyzed using cutting-edge monitoring techniques that examined pressure changes and assessed elongation, revealing significant discrepancies in the material's actual and predicted properties. In order to improve the longevity and safety of I-PSC girders, the results highlight the significance of strict material quality control, accurate prestressing force application, and optimum anchorage designs.

Keywords: I-PSC girders, wedge system, stresses, Prestressed concrete, anchorage system performance

1. Introduction

Currently, I-PSC Girder structures form one of the most delicate categories because of the strategic importance of infra-structures such as Highways, road bridges, rail bridges etc.I-PSC giders Used high tensile steel wires, with ultimate strength as high as 1725 MPa and yield stress over 1240 MPa. In 1939, he developed conical wedges for end anchorages for post- tensioning and developed double-acting jacks. Eugene Freyssinet is often referred to as the Father of Prestressed concrete. 1940 Magnel, G., (Belgium) developed an anchoring system for post- tensioning, using flat wedges More than 50% of bridges in now constructed with prestressed concrete (PC) [1]. Among all types of prestressed concrete bridges, precast PC I-girder bridges are the most common due to their inherent durability, low maintenance and assured quality. I-PSC girder is usually made of high-performance concrete and high-strength steel loaded at very high levels of tension. In recent years, according to changes in the social and technological environment, the expansion of the span length along with securing the clearance by reducing the height of the girder is continuously required. In the case of river bridges, it is necessary to secure water passage due to the increase of the design flood volume, and in the case of the overpass, the demand for 40m-class bridges is constantly increasing as the width of new or extended roads is planned to be 30m or more. However, in the case of designing a PSC I-girder bridge for a bridge with such a span, the competitiveness in terms of construction cost can be maintained, but there are issues such as the problem of overcoming the limitation of clearance and aesthetic due to the rapidly increased bridge height. Since steel bridges and PSC box-girder bridges, which are evaluated as alternatives to this, have a major weakness in economic feasibility, attempts to lower the height of PSC I-girders have continued until recently. Not only the United States but also many other countries are attempting to develop several more advanced PSC I-girders and use them in actual construction. It will be the driving force that leads the technology of the construction industry when engineers who should consider the price aspect, as well as the safety of people, are interested in these various construction methods and materials. This research based on

22m, 30, & 34m I-PSC Girder at 6 lanes of dabwali to chautala Project of Bharatmala Paryojana.In this Research work we are finding reason of failure of I-PSC Girder during Stressing & how to prevent them. In PSC girder Stressing is main part of work this start after 14 day and 28 days of girder casting. Many stages of girder stressing its depend on Length & height of girder. If Span of bridge more the 20m to 50m suggests I-shape of PSC girder. In this analysis failure of I-PSC Girder by Method of casting, Quality of Material like Anchor cone, wedges & HT wire &Method of girder Stressing

Fig 1:-I-PSC Girder

2. Purpose of the work:-

The key purpose of this research work is avoided the bridge accidents. In this research investigating the various failures come in girders during stressing likes as HT Wires failure, Anchor cone failures, live wages failures etc. and how to prevent them by using tool and techniques under guidelines. In it also determine the modified pressure and modified elongation. The ultimate goal of this research work is to avoid accidents. A quick review of all recent developments, software are used in structural engineering is provided in this report. Its explores how these tool and techniques and software can be used to strength the way structural engineering approach challenges and build more imaginative, efficient, durable and safer solutions for the built environment.

3. Research Objective

1. To investigate the failure during the stressing.
2. Find out various prevention of girder during stressing.

4. **RESEARCH METHODOLOGY**:-

There are two methods of prestressing:-

1. **Pre-tensioning**
2. **Post-tensioning**

Pre-tensioning is used to describe a method of prestressing in which the tendons are tensioned before the concrete is placed, and the prestress is transferred to the concrete when suitable cube strength is reached.

- Pre tensioning is one method of applying prestress.
- Tendons either pass through a single mould or a line of moulds for multiple members arranged end to end and can be attached at one end to fixed anchorage.
- The tendons are then tensioned from the fixed anchorage between external independent Anchorages to give the required tensile force in the tendon.

POST-TENSIONING

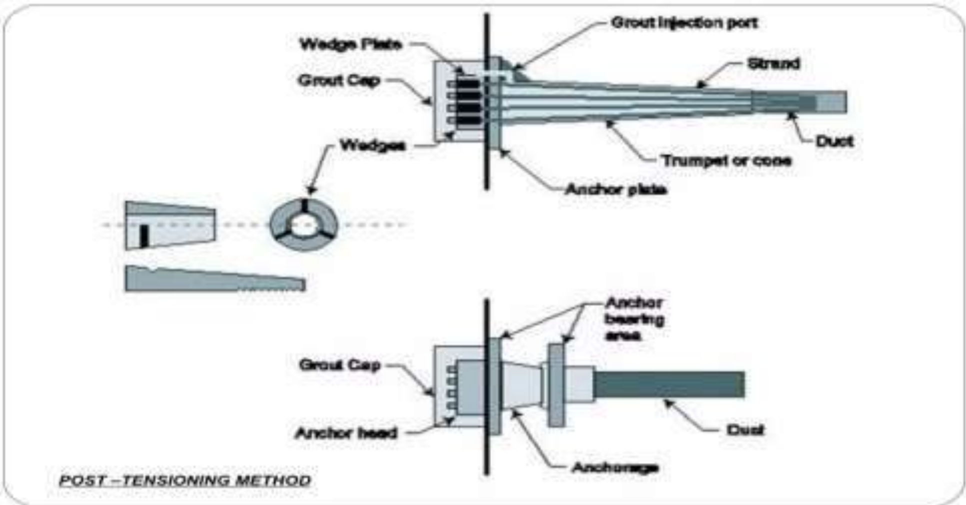
Post-tensioning- is a method of reinforcing (strengthening) concrete or other materials with high- strength steel strands called tendons.

- Post-Tensioning is another method of applying prestress to a concrete member.
- The tendon is placed in the correct position in the formwork with the dead-end anchorage and live end anchorage, through which the tendon passes.
- The concrete is then poured and left to harden.
- When the concrete has gained sufficient strength a jack is attached to the live end anchorage and the tendon stressed to the required force. The operation is to be carefully done as any error could impair the structural integrity of the member.

- The tension force in the tendon is transferred to the concrete as a compressive force by the reactions at the anchorages. The jack is then removed.

5. RESEARCH METHODOLOGY USE FOR ANALYZE THE DATA:-

In this Research work we are taken 10 girders samples finding reason of failure of I-PSC Girder during Stressing & how to prevent them by using post-tensioning method. In PSC girder Stressing is main part of work this start after 14 day and 28 days of girder casting. Many stages of girder stressing it are depending on Length & height of girder. If Span of bridge more the 20m to 40m suggests I-shape of PSC girder. In this analysis failure of I-PSC Girder by Method of casting, Quality of Material like Anchor cone, wedges & HT wire & Method of girder Stressing.



6. Limitation of the study

A various software and technique used in construction of girder like as Staad-pro software, civil Midas software and various techniques used for the better way so that this present a limitation of this study as regular up dating are required with respect to tool and technique and the various methods.

6.1 How can prevent the failure:-

How Civil Engineers Can Prevent Bridge Collapse

Engineers play an important role in the planning, construction, and ongoing maintenance of our nation's bridges in order to support their function, safety, and integrity. Here are a few ways civil engineers can combat environmental factors:

- In Stressing of I-girder main role is Quality of material like concrete, Anchor cone, Anchor head, Wedges & HT wire etc.
- HT wire, Anchor Cone, Anchor head & Wedges are test by Third party laboratory.
- Proper calculation of Modified Pressure & Modified Elongation.
- Grade of Concrete of Girder is not less than M40 Grade.
- Profiling sheathing pipe in proper Axis as per Drawing.

7. CONCLUSION:

In conclusion, addressing the failure of prestressed concrete (PSC) girders during stressing requires a multi-faceted approach. Rigorous quality control in material selection, meticulous construction supervision, and regular inspections are crucial. Implementing advanced testing methods and incorporating redundancy in design can enhance the reliability of PSC structures. Additionally, fostering a culture of continuous learning within the construction industry to stay updated on the latest advancements in technology and best practices is essential for preventing future failures in PSC girders during the stressing process. Here are some potential conclusions to consider:

- The failure may be attributed to deficiencies in the initial design phase, such as underestimation of loads, incorrect prestress force calculations, or insufficient consideration of material properties.

- Material defects, substandard quality of concrete or prestressing tendons or inadequate manufacturing processes may have contributed to the failure.
- Implement stringent quality control measures during material selection, manufacturing, and regularly inspect and test materials to ensure compliance with the failure could be a result of errors during the stressing process, such as uneven distribution of stress, incorrect prestress force application, or inadequate supervision.

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