To Consideration of Failures at Long Span of Steel Structures

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***Abstract*- Space structures are generally utilized in the construction of airport terminals, stockrooms, historical centers, and shopping centers where huge transverse space is required. They are architecturally appealing and structurally adaptable. Moreover, space structures are light in weight, which reduces the construction cost and help cover large zones of continuous spans effectively. In recent years, space structures have developed and discovered their utility in the cutting-edge world of construction. Hollow steel section members and nodes with improved properties have altogether affected their application in storage spaces. In comparison with the ordinary column-beam structure, long-range space structures are unpredictable in design and need explicit design rules. Thus, the chances of the generation of inaccurate data for mathematical models are high. Also, because of their simplicity, grid uniformity, and redundancy, structural engineers and contractors tend to assume their strength and stability. . An important observation is that welds are not as critical a cause of structural steel failures for statically loaded steel structures as implicitly understood in current regulations and rules for design and execution criteria. The cause of the failures is most often a gross human error rather than a combination of "normal" variations in parameters affecting the load-carrying capacity, as considered in normal design procedures and structural reliability analyses. Primary codes for the design of long-span steel structures lack procedural rules as the codes assume the behavior of a steel structure. Thus, experience in their planning, designing, construction, and assembly plays a fundamental role in avoiding failure.**
Keywords: Steel structures; static loading; structural failures; collapses; incidents; structural instability; gross human error; construction phase; welds; regulations; long span; etc.

I. INTRODUCTION

To the consideration based on the structures are 400 more than failures of the steel structures. These accidents have occurred in Sweden and elsewhere over the past four centuries. Likewise, progressive failure can occur in structures if the critical members are subjected to higher wind and snow load. Thus, to prevent the progressive failure of the structures, an additional factor of safety is to be utilized in critical members. Sensitivity analysis can be used to determine the critical members subjected to high loading and can be susceptible to failure. The purpose of the discussion is to identify what seem to be the major problems with regard to structural safety of steel structures, in order to reduce the risk for similar events to happen again. It should be emphasized that the background for the paper is not a research program but rather the result of the writer being commissioned for investigating a large number of structural collapses, incidents and structural damages which have occurred in Sweden and elsewhere. It could be argued whether the observations discussed in this paper are representative and whether the conclusions drawn in the paper are of a general nature. However, considering the large number of cases, constituting a fair portion of the accidents which have occurred with steel structures in the region, it is believed that the findings should have some general significance.

On the other hand, the collapse of single-layer framework structures (SLFS) might be initiated due to the buckling of a single member. Therefore, examining the stability of the individuals is very vital. SLFS shows more sensitivity to buckling than MLFS because of the transfer of the forces through just only one layer. The local buckling in SLFS may occur due to the snap-through buckling of single members in a localized area. Whereas the global buckling happens when a bigger region of instability is considered in the space steel structure.

II. TYPE OF FAILURES

- Shear failure
- Flexural failure
- Compression failure
- Tensile failure

III. REGION OF FAILURES

Generally steel structures are failed due to loading disturbance of the structures. This is a reflection of the fact that most civil engineering structures are indeed acting under service conditions where variations in loading is not great enough to cause fatigue problems.

3.1 Static loading, construction phase
3.2 Static loading, service phase
3.3 Fatigue damage

IV. CEILING COLLAPSE OF CHARLES DE GAULLE AIRPORT-TERMINAL 2E, FRANCE

On 23rd May 2004, the ceiling of Terminal 2E of the Charles De Gaulle Airport collapsed near gate E50. A 300 mm thick curved reinforced concrete precast slab was designed for the structure of 30 m width. Researchers suggested that a 30 m long concrete precast slab collapsed on to the boarding footpath. Four people lost their lives and three were critically injured.

4.1 Investigation Findings

The design concept used to construct the ceiling of the terminal was somewhat unusual. It was complex to understand and evaluate the force distribution since the 2D model made by the design office was not adequate as per code provisions. Redistribution of local forces from the struts to the panel was absent. Thus, the failure of a single member due to punching shear produced the collapse of domed concrete.

In the zone of concrete failure, the composite panels seemed to be loaded by a higher level of roof loads, increasing the punching shear by 50%. Also, the structural model failed to take into account the long-term effects of terminal structure. More than 400 firms were engaged with the venture, and a serious level of inefficient complexity was observed in the management of the project. A high likelihood of coordination error was inescapable because of the collective individual errors and mistakes. This is biggest hazardous of steel structures. The materials are used but every point is not fixed.

4.2 Causes of Failure

The following points describe the leading causes of the progressive collapse:

1. Inadequate shear stiffness was developed due to the insufficient design of shear reinforcement.
2. Dowel bars were deeply embedded inside the concrete shell and created cracks in the concrete roof.
3. Several cracks were formed as a result of higher-than-expected construction loads and differential moisture and thermal movements.
4. Investigation reports suggested that the margin of safety was lesser than anticipated during the design of failure.
5. Proper not well supervisions.
6. Not bounded with dowel bars to bars each others.

V. COLLAPSE OF ROOF OF SULTAN MIZAN ZAINAL ABIDIN STADIUM, MALAYSIA

The Sultan Mizan Zainal Abidin Stadium was constructed for hosting multi-purpose games in Kuala Lumpur, Malaysia. The seating capacity of the stadium was 50,000. The stadium was intended to have two-shell like. On 3rd June 2009, a tragic collapse of the roof of the stadium occurred soon after it had opened for one year. Luckily, there were no lives lost after the failure of the long-span space structure. This is a large capacity of the stadium of seating arrangement in this structure. Because more numbers of peoples are enjoy here.

5.1 Investigation Findings

After the failure of the roof of the stadium, an investigation committee was formed. The committee reported that the design of the stadium was not as per the codal provisions. The structural engineer didn't consider the support conditions while modeling the roof of the stadium. The span of the roof was very large and hence the roof was susceptible to the movements at the supports. The roof was constructed ineffectively and prompted additional stresses in the members at support because of misalignment. The quality of materials, nature of workmanship, and testing of preliminary materials were far below the standard prerequisites.

5.2 Causes of Failure

There are following points describe the main reasons behind the collapse of the roof of the Sultan Mizan Zainal Abidin Stadium:

1. After the failure of the structure, it was evident from the site debris that the steel components were defectively welded. Therefore, quality control in the pre-fabrication stage was lacking.
2. The design for temporary supports was not adequate. Thus, additional construction loads were applied to the supports.
3. No internal checks were conducted on the strength of the structure during the erection process.
4. During the modeling of the stadium, the critical factors for wind speed, wind direction, risk factor, and importance factor were not considered.
5. The orientation of the stadium was not based upon the topological conditions of the site. Moreover, the stadium was not designed for critically identified wind loads.
6. Due to the use of poor-quality material and improper design, the overall factor of safety of the structure was reduced.
7. Incorporation of poorly conceived plans, strategies, and faulty implementation of quality control checks and control systems by the management contributed to the collapse.
8. The managements are loose here because they are not well take precautions.
9. Materials testing report are wrong.
10. They should not gain proper strength of the steel structure.
11. Any steel member can take the secondary loads because the material is uniform and casted as a single piece, but joint behaves in a brittle fashion and takes some predicted loads but not all of it. Now let us consider a joint of a steel building.
12. Welding process are loose whose are create major problems of the structure.

VI. CONCLUSIONS

A general conclusion is that the cause of failures most often is a gross human error, in a few cases a combination of two gross human errors. Based on experience from failures, of which only a fraction and then mostly with major structures are presented in the literature, several changes would be required in regulations and rules for the design and execution of steel structures. One important matter regards the evaluation of welds. The current emphasis on internal discontinuities in welds should be pared with a more strict evaluation of external discontinuities, in particular, for welded structures with fatigue loading. It is important that lessons be learned from structural failures in a more coordinated and guided way than hitherto, in order to make effective use of manpower and other resources in the design and execution of structures. Proper welding of each elements and each part of the structures that are work proper at that place.

REFERENCES

[1] Syed, M. Black Box Thinking, John Murray (Publishers), London, 2015.
[2] Tranvik, P., and Alpsten, G. Dynamic Behaviour Under Wind Loading of a 90 m Steel Chimney, Alstom and Stålbyggnadskontroll AB, March 2002.
[3] Tranvik, P., and Alpsten, G. Structural Behaviour Under Wind Loading of a 90 m Steel Chimney, Wind & Structures, Volume 8, No. 1, January 2005.
[4] Execution of steel structures and aluminium structures - Part 2: Technical requirements for steel structures, EN 1090-2:2208+A1:2011.
[5] Alpsten, G. Uncertainties and Human Errors in the Design and Execution of Steel Structures, IABSE Workshop on Ignorance, Uncertainty and Human Errors in Structural Engineering, Helsinki 15-16 February 2017.
[6] Alpsten, G. On the Use of Reliability Assessment Methods for Structural Design, Euro-SiBRAM Colloquium, Prague June 2002.
[7] Alpsten, G. Handbok TR-stål/N (Handbook TR-steel/N, in Swedish), Stålbyggnadskontroll AB, December 2012.
[8] Alpsten, G. Confidential technical report referred to in the judicial proceedings of the collapse in question, Stålbyggnadskontroll AB, 2008.
[9] FEMA. Prestandard and commentary for the seismic rehabilitation of buildings. FEMA-356. Federal Emergency Management Agency, U.S.A., 2000.
[10] FEMA. Recommended seismic design criteria for new steel moment-frame buildings. FEMA-350. Federal Emergency Management Agency, U.S.A., 2000..