A CASE STUDY OF THE COLLAPSE OF A 45M STEEL STRUCTURE (COAL BUNKER) DUE TO HIGH INTENSITY DYNAMIC LOADING

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SUMMARY

During the cyclone of November 1977, which occured on the east coast, considerable damage was done to the structures in progress. Tower cranes, radio broadcasting and transmission towers, designed for resisting high winds, were found damaged. The extent of loss of steel at Vijayawada Thermal Station was about 1000 tonnes.

The cyclone had crossed the structure when under erection. The photographs show the extent and severity of the damage due to high intensity dynamic loading caused by the cyclone.

INTRODUCTION

The cyclone which crossed the coastal district of Andhra Pradesh in South India on November 19, 1977, had taken a toll of 20,000 human lives and property worth 300 million dollars. The damages to the Vijayawada town and its surrounding areas (which are 80 km away from the coast) where the cyclone had crossed with a velocity of 160 km per hour was very severe. The wind velocity had initiated tidal waves as high as 6 metres which resulted in considerable loss of life

DETAILS OF THE CYCLONE

The cyclone was observed and photographed by the satellite well in advance. However, it could not be predicted where it would cross the coast. On November 18, it was predicted that it would cross Madras city the next day. However, it moved a distance of 140 km during the 12 hours from 8.00 AM to 8.00 PM on that day. The eye of the storm was clearly visible on the radar scope of the air route surveillance radar installed at the Madras airport. After 8.00 PM when the cyclone eye was 130 km south of Madras, it picked up speed and passed Madras at midnight on November 18. It had hit Chirala town which is 300 km north of Madras on November 19, at 3.00 PM. Its fury lasted till midnight of November 19, by which time the power lines were completely disturbed over an area of 6500 sq. km. The fury was felt along 400 km coast line. The wind velocity recorded was 160 to 200 km per hour.

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PROBLEMS ENCOUNTERED WITH STRUCTURES UNDER EXECUTION

Prediction of cyclone will enable concerted evacuation programme. However, very little could be done to save the existing structures which were not designed for such adverse conditions. The problem was critical for structures which were under construction.

The damaged bunker bay is a typical case of a tall narrow structure with its unavoidable erection problems. This structure needed a careful erection sequence.

The erection equipment like the derrick post with powerwinch was to be moved in a programmed sequence bearing in mind the availability of equipment and labour.

The affluent countries solve most of their difficulties by using huge and expensive machinery. The developing countries cannot afford the use of capital intensive machinery because the cost of these may equal the cost of the projects themselves. Hence, the methods adopted to prevent the damages by natural calamities should suit the needs of the developing countries. The structures should be designed to posses secondary stability. However this may escalate the overall cost.

DETAILS OF THE BUNKER BAY (K & L)

The coal bunker bay consists of 6 bunkers for each boiler. There were two boilers to be erected in the first stage of construction. The complete project has 6 boiler units. The 12 bunkers were entrusted for execution to two agencies for hastening the progress of work and hence were tackled independently.

The progress of work of the first agency was more at the time of cyclone. Therefore, more damages occured in the works executed by the first agency. Hence this is considered for the case study.

The bunker bay consists of K and L rows standing independently. The length of the K and L rows for the first unit is 75 metres and for the second unit is 75 metres which includes a junction tower for transfering coal. The span of the K and L row is 10.5 metres. The height of the bunker bay is 44.5 metres

In Figs. 1, 2, 3 and 4, the position of the columns for K row, L row and the erected portion at the time of cyclone can be seen. In particular, Fig. 1 shows the schematic plan and elevation of the Vijayawada Thermal Scheme. Fig. 2 shows the elevation of the K row and L row columns. Fig. 3 shows the end view of these columns. The broken lines indicate the members that were still to be positioned. Fig. 4 shows the cross sectional details of the columns adopted.

The columns were of heavy sections where they supported the bunkers. They were made up of plate girders of 1400 mm x 600 mm at the base reducing to 1000 mm x 600 mm at 36.7 metres height. The weight of lighter column was 28 Tonnes and that of the heavier column was 45 Tonnes. The columns were prefabricated. The heaviest piece weighed 20 Tonnes. The units were transported on trolleys and after positioning, were welded at site. Each piece was tied up with the next column with cross beams. The sequence of welding tie beams and the cross beams and bracing depended on the movement of the derrik.

The sequence of erection was based on the following constraints.

1. Shortage of raw materials
2. The scheduling of different agencies
3. Movement of the transporting vehicles
4. Storage of machinery to be erected
5. The alignment of the columns

The wind bracings had been provided only in some bays leaving openings for pipe lines etc. As can be seen in Fig. 2, the other bays were only tied up with beams at various levels.

DAMAGES EXPERIENCED BY THE STRUCTURE

The photographs in Figs. 5 to 8 clearly show the extent of the damage. Fig. 5 shows the aerial view of the damages. The heavy flange plates of 28 mm to 50 mm thickness were found sheared at several places. In Fig. 6 this can be seen. Fig. 7 shows the overall view of the damaged columns. The overturned tower crane is shown in Fig. 8.

According to the Indian Standard Code IS: 875-1964 (Ref. 1) the location of the thermal station is outside the zone for which 200 km per hour wind is considered. The area is outside the coastal danger zone. However, this area has experienced wind velocity and force larger than that contemplated by the code. Also, the provision given in the safety code Indian Standard Code IS: 7205-1974 (Ref. 2) for erection of structural steel work is not adequate to deal with such abnormal wind loads.

CONCLUSIONS

The damages experienced by the structure under execution was unprecedented and has indicated the following.

1. The need for a separate code for structures under erection in the cyclone prone areas.

2. The inadequacy of the existing codes in defining the cyclone prone areas of India.

3. The inadequacy with regard to the knowledge of maximum forces that must be resisted during abnormal dynamic loading especially for structures under erection.

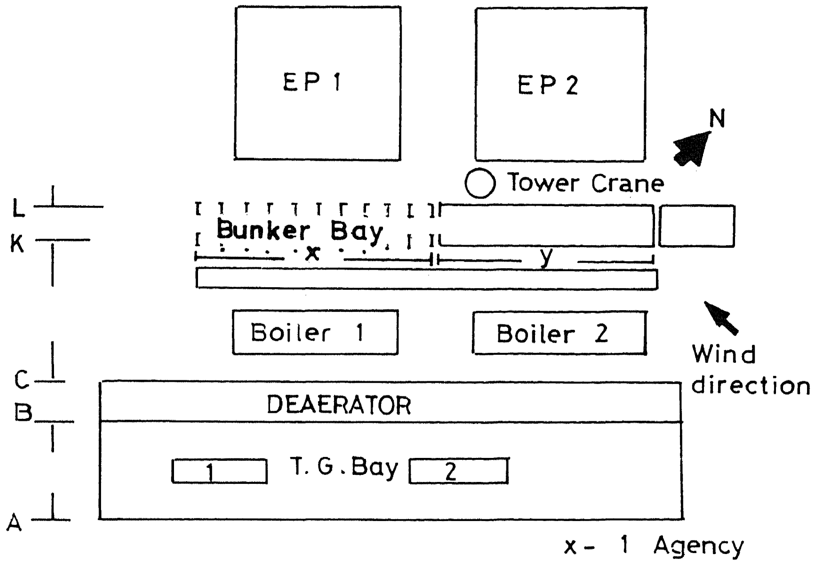
4. The need for proper analysis for estimating forces in a structure under erection.

5. The need for quantifying the wind force in the danger areas.

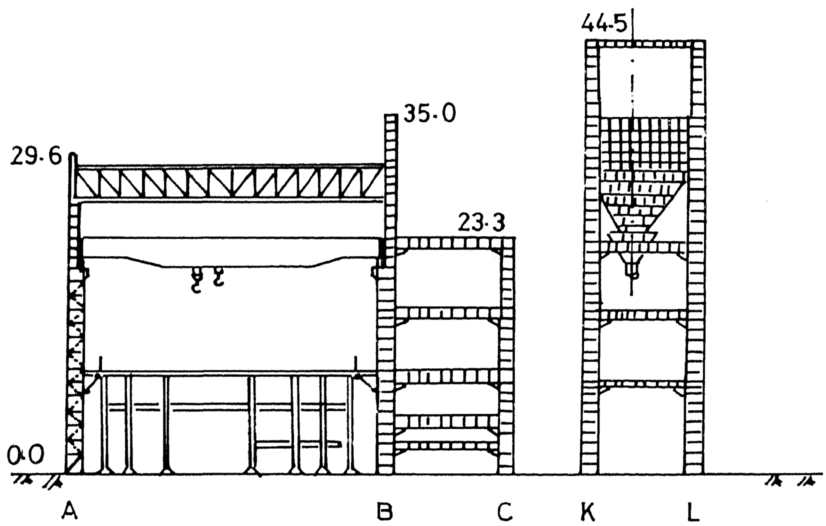
REFERENCES

1. Indian Standard- Code of Practice for Structural Safety of Building, Loading Standards (Revised) IS: 875-1964, Indian Standards Institution, New Delhi, 1964, pp. 30

2. Indian Standards- Safety Code for Erection of Structural Steel Work, IS: 7205-1974, Indian Standards Institution, New Delhi, 1974, pp. 13

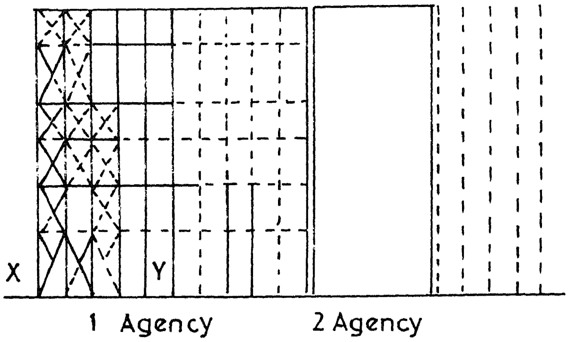


(a) Schematic Plan

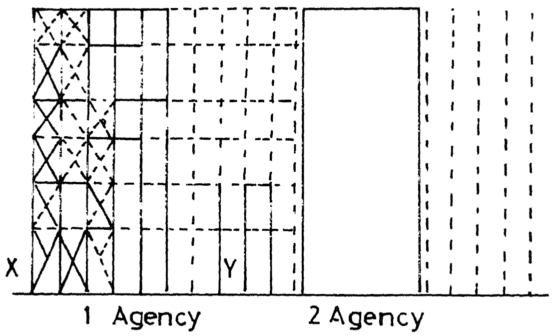


(b) Elevation of A B C K & L Rows

FIG 1 VIJAYAWADA THERMAL SCHEME
(South India)



K ROW



L ROW

FIG 2 ELEVATION OF COLUMNS

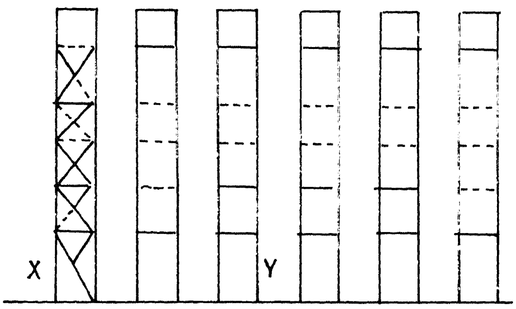
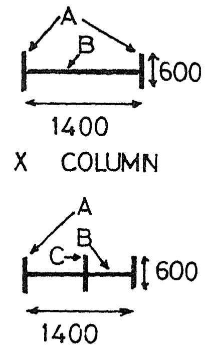


FIG 3 END VIEW OF COLUMNS



Y COLUMN

	X	Y
A Flange	32	50
B Web	20	40
C Centre	-	40

FIG 4 TYPES OF COLUMNS

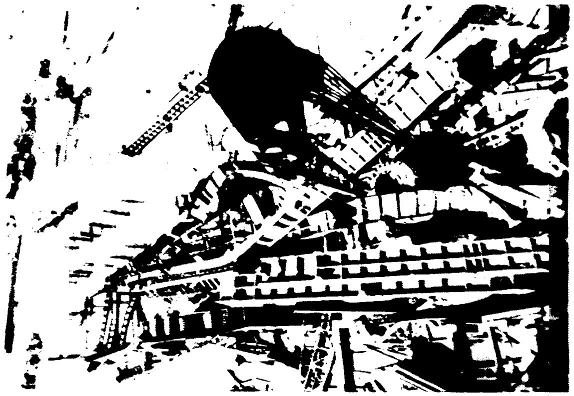


FIG 5 AERIAL VIEW OF THE DAMAGES

FIG 6 TEARING OF FLANGE PLATES

FIG 7 DAMAGED COLUMNS

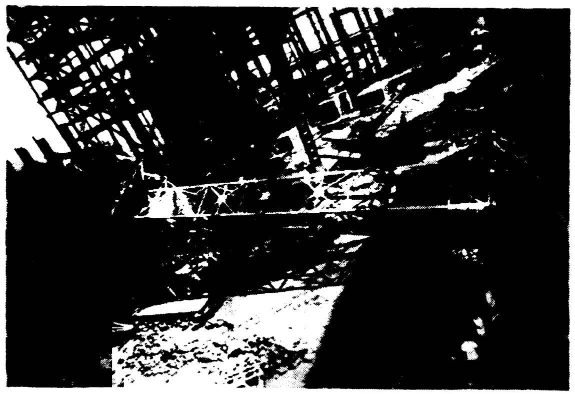


FIG 8 OVERTURNED TOWER CRANE