Progressive Collapse Analysis of Steel Truss Foot Over Bridge

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Abstract - *The progressive collapse is that the phenomenon of the worldwide failure of the structural system results from the failure of the only element of it. The good research work made for the progressive collapse of the building structure, but the very small response has shown towards the bridge structure. For this study, we consider 4 types of 25m steel truss foot over bridge models by using Staad Pro Connect Edition V 22 software and are designed according to the Indian Standard Codes, for all load combinations. This model is to be an analysis for progressive collapse analysis as per latest GSA guideline 2016. The linear dynamic analysis is administered for a steel truss foot over bridge considering different loadings like dead, live, wind and seismic using Staad Pro Connect Edition V 22 software. After the design load is applied, the live load is increased until the bridge model collapses. Although the collapse process differs depending on live load distribution for both steel truss bridge models collapse due to buckling of compression members. When the live load is applied incrementally by 25% on the span, bracing member starts yielding in model 1 & 3 whereas model 2 & 4 is safe. When live load increased by 50% bracing members starts failing and compression members like upper chord and column starts yielding. When Live load increase by 75% and 100% case bracing, upper chord, walkway beams and columns start failing in all four models. As utilization ratio defined by ultimate stress to allowable stress, bridge model-2 i.e. A-type with sub brace is more resistible to collapse compare to rest of models. This study clarifies the collapse process due to incremental live load and effective truss arrangement for steel truss bridge.*

***Key Words*: Steel Truss bridge, Progressive Collapse, Incremental Live Load, Linear Dynamic Analysis, Staad Pro Connect Edition, IRC 6-2017.**

1.INTRODUCTION

India is a developing country. Transportation facilities and their related infrastructure development play a vital role in the progress of developing countries like India. Bridges are one of the foremost important engineering infrastructures utilized in transportation. Railway bridges are constructed to connect to platform separated by railway track to carry pedestrians safely from one platform to another platform and also to exit station. Nowadays Steel foot over bridges is widely adapted by railways. Steel bridges provide overall ease and economy for construction. Steel bridges are easy to construct within a short period of time. It is environment-friendly and commuter – friendly. Foot over bridges is provided at platform in such a place where it can carry maximum pedestrian traffic at peak hours and also at non peak hours. And also, it could be very convenient to users from both sides of platform. Steel fobs can be used right from the time construction is over. A structure undergoes progressive collapse when a primary structural element fails, leading to the failure of adjoining structural elements, which causes structural failure. It also defined as extent damage or collapse that's disproportionate to the magnitude of initiating event. Progressive collapse analyses are intended to work out the capacity of a structure either to resist an abnormal loading.

1.1 Progressive Collapse

A structure undergoes progressive collapse when a primary structural element fails, resulting in the failure of adjoining structural elements, which causes structural failure. It also defined as extent damage or collapse that is disproportionate to the magnitude of initiating event. Progressive collapse analyses are intended to determine the capacity of a structure either to resist an abnormal loading.

1.2 Causes of Progressive Collapse

In the history of bridges, lots of bridges are collapsed due to various reasons. Mostly there are two main reasons which are Natural factors and Human factors. Natural factors are Floods, Earthquakes, landslide, debris flow, hurricane, and typhoons, scouring these natural calamities are unavoidable which causes plenty of damage to the structure. Human factors are Imperfect design & Construction, collision, Terrorist Attack, Lack of Inspection & Maintenance, Heavy pedestrian Traffic.

2. AIM AND OBJECTIVE

To study of progressive collapse analysis of steel truss foot bridge having span of 25 meter. The Dissertation work is being carried out to achieve the following objectives:

1) Modelling of the steel foot over bridge in STAAD PRO CONNECT EDITION V22 software. 2) Study the structural behavior of the foot over bridge under different load conditions like gravity loads, wind load, seismic load as per IRC. 3) Study the concept of progressive collapse. 4) Perform

the progressive collapse analysis of the steel foot over bridge using STAAD PRO CONNECT EDITION V22 software by Incremental Live Load.

3. MODELLING AND ANALYSIS

3.1 Modelling Work

To study the structural behavior of the foot bridge under different loading conditions like gravity, seismic, wind and progressive collapse behavior of the steel truss foot bridge under incremental live load. The following details are used.

Table -1: Details of Steel Truss Bridge.

Name of parameter	Specification
The span of the bridge	25 m
Type of superstructure	Steel foot bridge
No. of supports	2
Width of each span	3.5 m
Height of walkway above ground	6 m
Bridge location	Pune
Seismic zone	III
Zone factor	0.16
Importance factor	1.2
Response reduction factor	3
% Damping	2 %
Wind speed	39 m/s

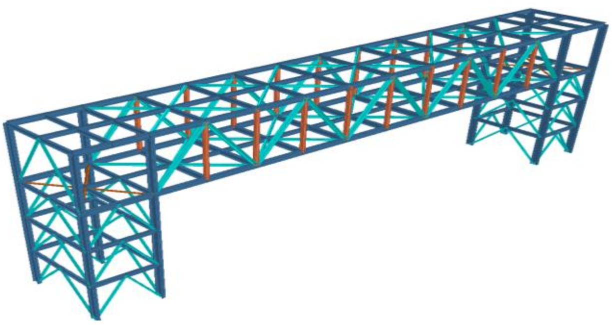

Fig -1: A-Type Truss Bridge

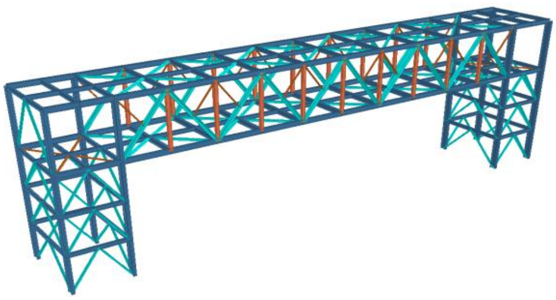

Fig -2: A-with Sub Brace Truss Bridge

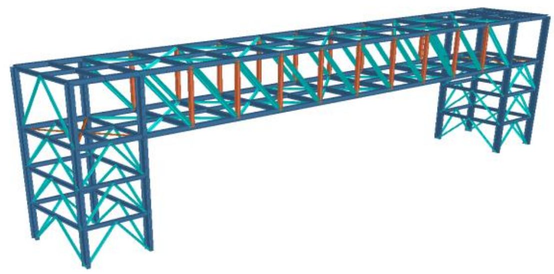

Fig -3: N-Type Truss Bridge

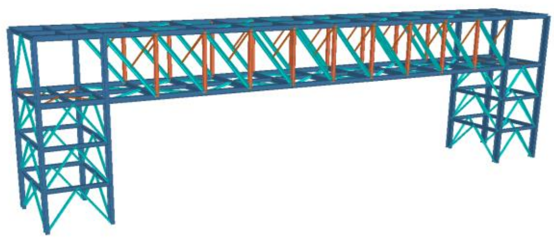

Fig -4: N- with Sub Brace Truss Bridge

3.2 Analysis Work

The part analysis work has been carried out in STAAD PRO CONNECT EDITION V 22 Software to check the progressive collapse of the steel truss bridge at actual dead load and incremental live load according to the acceptance criteria suggested by GSA (2016) Revision 1. All other load combinations & loads like dead load, live load, wind load, seismic load considered as per IRC 6 (2017).

4. RESULT AND DISCUSSION

4.1 Base Shear Results

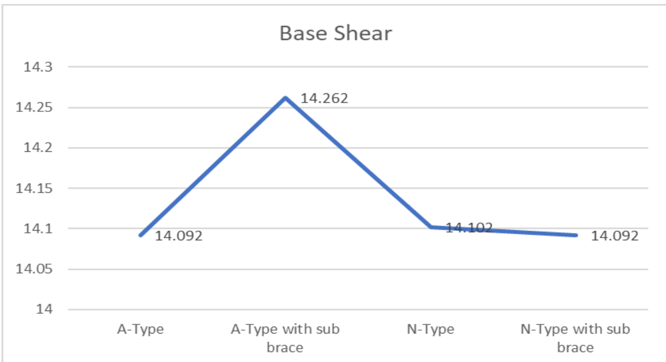

Chart -1: Base Shear Comparison

Base Shear (KN)			
A-Type	A-Type with sub brace	N-Type	N-Type with sub brace
14.092	14.262	14.102	14.092

Table -2: Base Shear Result Comparison

4.1 Vertical Joint Displacement

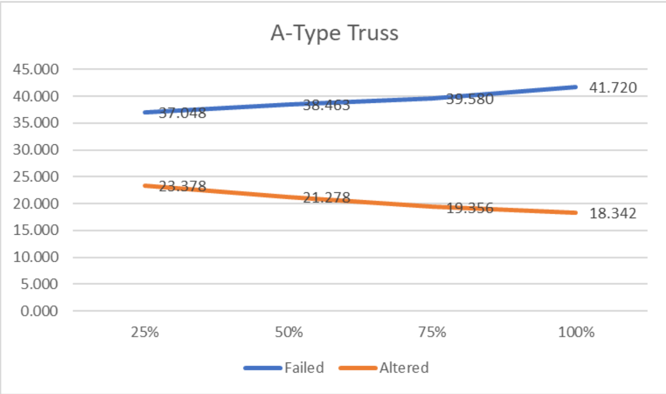

Chart -2: Vertical Displacement For A-Type Model

Vertical Joint Displacement (mm)		
Actual Model	23.680	
25 % Increment model	37.048	23.378
50 % Increment model	38.463	21.278
75 % Increment model	39.580	19.356
100 % Increment model	41.720	18.342

Table -3: Vertical Displacement For A-Type Model

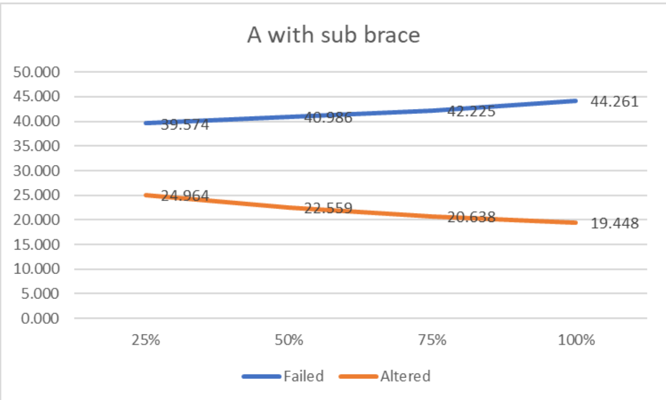

Chart -3: Vertical Displacement For A-with Sub Brace Model

Vertical Joint Displacement (mm)		
Actual Model	24.964	
25 % Increment model	39.574	24.964
50 % Increment model	40.986	22.559
75 % Increment model	42.225	20.638
100 % Increment model	44.261	19.448

Table -4: Vertical Displacement For A-with Sub Brace Model

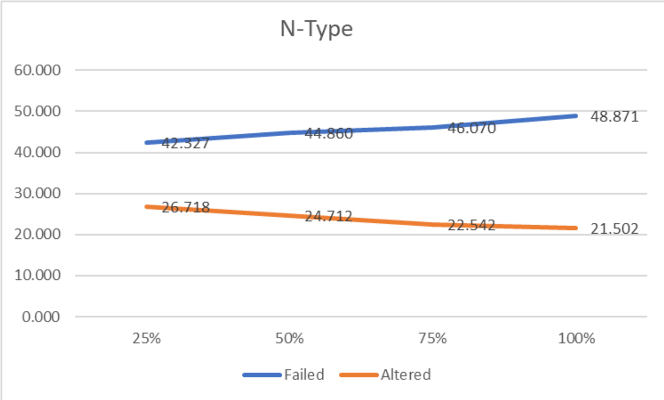

Chart -4: Vertical Displacement For N-Type Model

Vertical Joint Displacement (mm)		
Actual Model	26.875	
25 % Increment model	42.327	26.718
50 % Increment model	44.860	24.712
75 % Increment model	46.070	22.542
100 % Increment model	48.871	21.502

Table -5: Vertical Displacement For N-Type Model

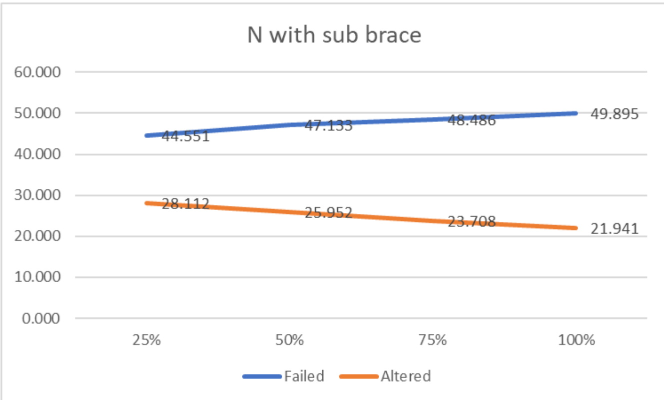

Chart -5: Vertical Displacement For N-with Sub Brace Model

Vertical Joint Displacement (mm)		
Actual Model	28.112	
25 % Increment model	44.551	28.112
50 % Increment model	47.133	25.952
75 % Increment model	48.486	23.708
100 % Increment model	49.895	21.941

Table -6: Vertical Displacement For N-with Sub Brace Model

5. CONCLUSIONS

In this study, progressive collapse analysis for a continuous steel truss bridge with total span of length 25m was carried out for four different types of truss arrangement and with four different live load distribution. The collapse process is different depending on increase in live load at each stage. Live load is increase by 25 % (1.25 times of actual live load) in each stage.

In model-1 and model-2 where live load is fully applied on the span, Bridge model 1 and 2 collapse due to the buckling of upper chord at the center span. The collapse process and the ultimate strength of bridge model 1 and 2 are almost the same and the side and center span ratio does not have an effect. The number of yield members are more than 60 at buckling and the applied load seems to be redistributed effectively after altering the members.

In model-3 and model-4 where live load is fully applied on the span, Bridge model 3 and 4 collapse due to the buckling of upper chord at the center span. The collapse process and the ultimate strength of bridge model 3 and 4 are almost the same and the side and center span ratio does not have an effect. The number of yield members are more than 73 at buckling and the applied load seems to be redistributed effectively after altering the members.

The ultimate strain of a tensile stress of member is less than 10 % in all the cases. It is therefore concluded that the bridge model does not collapse due to breakage of the tensile member but buckling of the compressive members.

Summarizing the above results, bridge models collapse due to buckling of the compressive member in all the cases. When the live load is fully applied in the center span, the span ratio does not affect the ultimate strength which is sufficiently high.

It is found that model 2 is better to resist to collapse than model 4 and has higher redistribution of loads.

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