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A Study of Reliability Assessment of Truss Girder Railway Bridge

A. V. V. Satyanarayana[1], M. K. M. V.Ratnam[2], R. Syam Babu[3], Dr. U. Ranga Raju[4]
[1,2,4]Department of Civil Engineering, DNR College of Engineering & Technology, Bhimavaram, Andhra Pradesh, India
[3]Department of Civil Engineering, JNTUK Engineering College, Kakinada, Andhra Pradesh, India

ABSTRACT

Bridges are generally used to cross a stream or a river. Which are used for different purposes such as, if it is used to cross cycles and animals, then it is called as foot bridges. If it used for highway traffic then it is called Highway Bridge, or if it is used to carry railway loading then it is called Railway Bridge, Over the above all bridges the cost of railway bridge is more than the other bridges. The project is a study on reliability of the Railway Bridge Truss changes with decrease in area due to corrosion and how reliability varies if steel strength is below than actual (or) its strength reduced due to corrosion. The tension members are analyzed for the design strength due to yielding of gross section and compression members are analyzed for the design strength. The limit state equations are taken from the clause 6.2 and 7.1.2 of IS 800:2007. The reliability analysis is done for the Railway bridge truss of span 39.0m. Reliability of truss members investigated for different combinations using Hasofer –Lind technique and MATLAB software. System reliability was accused considering various levels of reduction in area and the variation of system reliability was calculated.

Keywords: Foot Bridges, Highway Bridge, Railway Bridge, Hasofer-Lind technique, MATLAB software.

I. INTRODUCTION

Bridges are structures built for carrying the road/railway traffic or other moving loads over a depression or gap or obstruction such as a river, channel, canyon, valley, road or railway. If the bridge is constructed to carry railway traffic, then it is known as a railway bridge. If, however, it is constructed to carry highway traffic, it is known as a highway bridge. There may be a combined highway and railway bridge to carry both the railway as well as highway traffic. Some bridges, constructed exclusively to carry pedestrians, cycles and animals, are known as foot bridges while those constructed to carry canals and for pipe lines are known as aqueduct bridges.

Bridges are made of different material such as timber, stone masonry, brick masonry, concrete and steel. Timber bridges are constructed only over small spans and for temporary purpose, to carry light loads. Masonry bridges are also constructed for shorter spans. Concrete bridge, both of reinforced cement concrete as well as of prestressed cement concrete are constructed over moderate to high spans, to carry all types of loads. Concrete arch bridges have been constructed of spans up to 200 m. similarly, steel bridges, and are constructed both over moderate to high spans as well as for highway trafficular loads. In India steel bridges are commonly used for railways for all types of spans.

Truss Girder Bridges:

The truss girder bridges are normally used for spans greater than 30 m. Truss girder bridges are also known as open web girder bridges or lattice girder bridges. In contrast to the plate girder bridges where there is continuous web, the truss girder bridges have open web in the form of diagonals and verticals. The chord members from the perimeter of the truss figure while the end members form a part of the web; the end members are also called end posts. The upper most members form the top chord, while the lower most members from the bottom chord. Both chord members as well as web members are absolutely necessary for the stability of the truss girder, and hence they are known as main members.

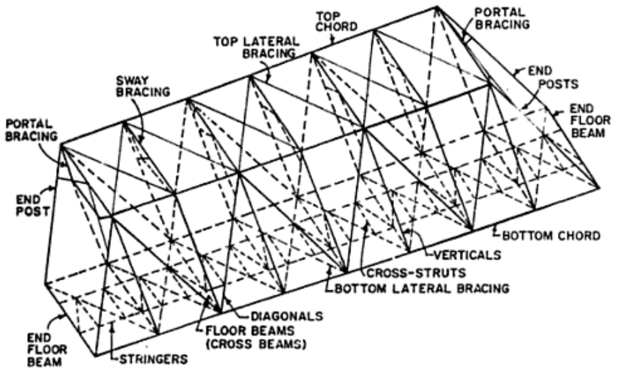

Figure 1. Diagrammatic View of a Through Type Truss Girder Bridge

Reliability:

The computational assessment of system reliability of structures has remained a challenge in the field of reliability engineering. Calculation of the failure probability for a system is generally difficult even if the potential modes are known or can be identified, as available analytic methods require determination of sensitivity of performance functions, information on mutual correlations among potential failure modes, and determination of design points.

In the field of reliability assessment of structure, the most direct way of analysis is to evaluate the failure rate of component based on the failure data of similar components in the past.

The other method is to calculate the structural reliability of component, treating many parameters and data involved as statistical variables with their probability distribution functions (pdf's).

Euro Code Recommendations:

Euro code 1 gives recommended minimum value for the reliability index β for variable loads at the ultimate limit state, for different classes of structure. Reliability class 1 (RC1) has low consequences for loss of human life and economic, social or environmental consequences small or negligible. Class (RC2) is medium and considerable. Class (RC3) is high and very great.

Table 1 : Euro code-Basis of Structural Design:

Reliability Class	Minimum values for β	
	1 year reference period	50 years reference period
RC3	5.2	43
RC2	4.7	3.8
RC1	4.2	3.3

Table 2 : The reliability index can be converted into annual failures of probability as follows:

Reliability Class	Minimum values for β
RC3	10^{-7}
RC2	10^{-6}
RC1	10^{-5}

Proposed Work:

In this thesis work, a method based on member forces approximations is proposed for structural system reliability assessment applicable to mixed systems. The aim of this work is to use an Advanced Level 3 method using Hasofer-Lind technique for structural reliability analyses. The Member Forces are taken from the STAAD. The code is developed in MATLAB® that calculates the reliability index following the iterative steps of advanced level 3 method using Hasofer- Lind technique methodology, with a considerable reduction in calculation time.

II. METHODS AND MATERIAL

Need for probabilistic Analysis:

If a structure is designed and constructed according to given requirements it can be assumed that the structure is efficient and fulfils the given requirements. However, this statement is valid only with limitations.

As a consequence of this there are three main issues to be considered when assessing an existing structure:

- The effect of possibly changed requirements to the structure on the structural performance.
- Validation of the design assumptions and assessing the effect of possible deviations from these on the structural performance.
- Assessing the condition and residual capacity and service life of the structure.

Value of information:

A structure can be assessed by collecting (measuring / monitoring / inspecting / testing) information (through indicators) about the exposure, the vulnerability and the robustness. Sometimes information about indicators are not only collected specifically through an assessment/inspection but also continuously through monitoring. The collection of information then provides the basis for deciding on the required and relevant structural reassessments and modifications. Important issues must be considered when planning inspections and assessing inspection are

- Development of a hypothesis in regard to the phenomena being inspected and
- The significance of the inspected indicators in regard to the hypothesized phenomena.

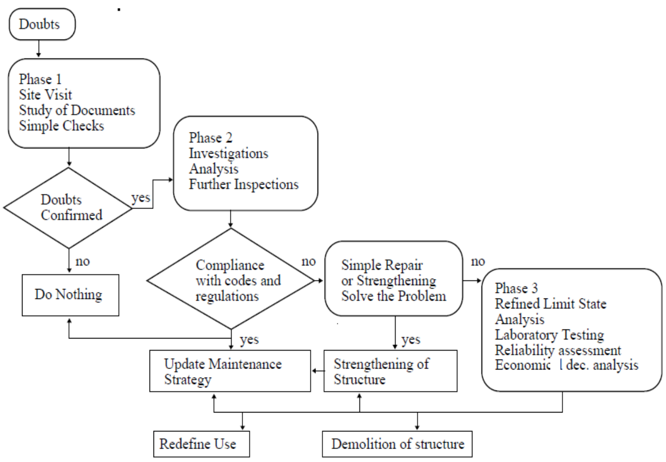

Figure 2. General adaptive approach for the assessment of structures

Strength Based Limit State:

They are potential modes of structural failure. For steel members, the failure may be either yielding (permanent deformation) or rupture (actual fracture). The strength based limit state can be written in the general form:

Required strength < Normal strength

The required strength is the internal force that you derive from your analysis of the structure being designed. The normal strength is predicted capacity of the beam, for example in bending, it is the maximum moment, M, that the beam is capable of supporting (a function of the stress capacity of the materiel and the section properties of the member). Typically the structural design specification uses the following variables to denote the different strengths:

P= Axial Force
M= Bending Moment
V= Shear force
R= reaction force

The basic reliability problem:

The basic structural reliability problem considers only one load effect S resisted by one resistance R. Each is described by a known probability density function, $f_S(\ )$ and $f_R(\ )$ respectively. It is important that R and S are expressed in the same units.

$$
\begin{aligned}
p_f &= \mathrm{P}(\mathrm{R} \le \mathrm{S}) \\
&= \mathrm{P}(\mathrm{R} - \mathrm{S} \le 0) \\
&= \mathrm{P}\left(\frac{R}{S} \le 1\right) \\
&= P(\ln R - \ln S) \le 0
\end{aligned}
$$

Or, in general

$$= P(G(R, S) \le 0)$$

Where G ( ) is termed the limit state function and the probability of failure is identical with the probability of limit state violation.

The probability of failure becomes:

$$p_f = P(R - S \le 0) = \iint f_{RS}\,(r, s)\, dr\, ds$$

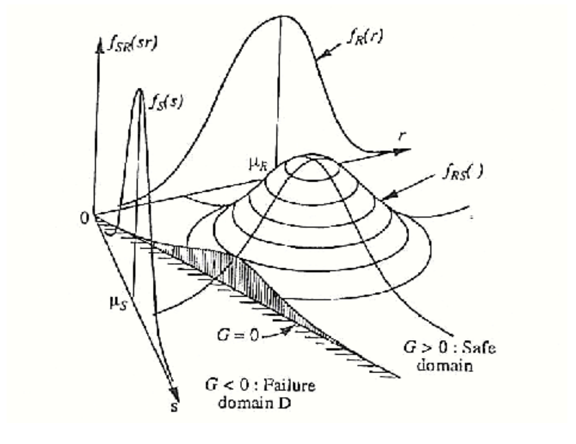

Figure 3. Joint density function fRS(r,s), marginal density functions fR(r) and fS(s) and failure domain D, (Melchers, 1999)

Levels of reliability methods:

There are different levels of reliability analysis, which can be used in any design methodology depending on the importance of the structure.

1. In level I methods, the probabilistic aspect of the problem is taken into account by introducing into the safety analysis suitable “characteristic values” of the random variables, conceived as fraction of a predefined order of the statistical distributions concerned.
2. Reliability methods, which employ two values of each uncertain parameter (i.e., mean and variance), supplemented with a measure of the correlation between parameters, are classified as level II methods.
3. Level III methods encompass complete analysis of the problem and also involve integration of the multidimensional joint probability density function of the random variables extended over the safety domain.
4. Level IV methods are appropriate for structures that are of major economic importance, involve the principles of engineering economic analysis under uncertainty, and consider costs and benefits of construction, maintenance, repair, consequences of failure, and interest on capital, etc.

Hasofer – Lind Method:

Identify the load and resistance parameters ($X_1,\ldots,X_n$). Formulate the limit state function, $g(X_1,\ldots, Xn)$, such that $g < 0$ for failure, and $g \geq 0$ for safe performance.
The basic variables are then normalized using the relationship

$$Z_i = \frac{X_i - \mu_i}{\sigma_i} \quad i = 1,2,\ldots,n$$

Where $\mu_i = \mu_{X_i}$ in the Z coordinate system the failure surface is a function of Z_i. Using equation 3.23 in the failure function and equating it to zero, the failure surface equation is written in the normalized coordinate system, i.e. the Z coordinate system, this failure surface also divides the design sample space into two regions, safe and failure.

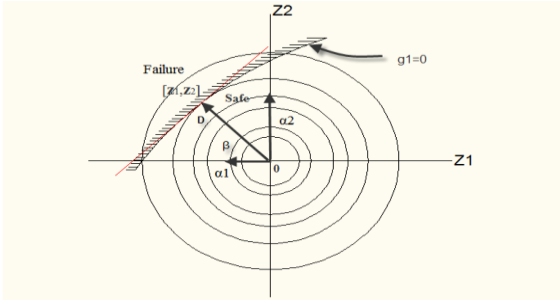

Figure 4. Formulation of safety analysis in Normalized coordinates.

Theoretical Analysis of Tension Members Using Hasofer – Lind’s method:

According to IS 800-2007 design strength of axial tension, $T_{dg,}$ as governed by yielding of gross section, is given by

$$T_{dg} = \frac{A_g f_y}{\gamma_{m_0}}$$

Where
f_y = Yield stress of the material.
A_g = Gross area of cross section.
γ_{m_0} = partial safety factor for material.
The following table is from IS 800 -2007, table -5 Partial safety factors for materials.

S. No	Definition	Partial Safety Factor	
i)	Resistance, governed by yielding, γ_{m_0}	1.10	
ii)	Resistance, of member to buckling, γ_{m_0}	1.10	
iii)	Resistance, governed by ultimate stress, γ_{m_1}	1.25	
iv)	Resistance of connection:	Shop Fabrications	Field Fabrications
a)	Bolts – Friction Type, γ_{m_f}	1.25	1.25
b)	Bolts – Bearing Types, γ_{m_b}	1.25	1.25
c)	Rivets, γ_{m_r}	1.25	1.25
d)	Welds, γ_{m_w}	1.25	1.50

Theoretical Analysis of Compression Members Using Hasofer – Lind method:

Design of compression members as per IS 800 -2007
Design compressive strength P_d , of a member is given by

$$P_d = A_e f_{cd}$$

A_e =effective sectional area.

f_{cd}= design compressive stress.

The design compressive stress (f_{cd}) values are in table 9(a), 9(b),9(c),9(d) of IS 800 – 2007 as per buckling class a,b,c,d.

Analysis of bridge truss reliability:

Here we are considering primary as well as secondary members for the analysis of System reliability. Hence mixes system is considered for system reliability calculation.

Reliability of mixed system is given by

$$P_{ss} = P(E_1 \cap E_2 \cap \ldots \cap E_n)$$

$$P_{ss} = P(E_1)P(E_2)\ldots P(E_n)$$

Where $P(E_1)$ = the event of subsystem 1.

$P(E_2)$ =the event of subsystem 2.

$P(E_n)$ = the event of subsystem n.

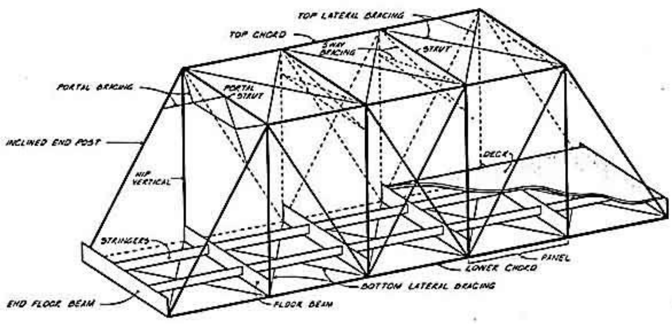

Figure 5. Analysis of Truss Girder Railway Bridge

Different Loads Calculation on Bridge:

a) Dead load
b) Live load
c) Impact load
d) Wind load

Dead load calculation:

Dead load is the weight of the bridge truss and any other permanent load attached to it. Now permanent load on floor system was calculated as follows on the truss girder bridge. With the relevant given data the calculations are as follows.

i) Weight of stock rails per m of track = 2 × 0.44 KN/m

ii) Weight of guard rails per m of track = 2 × 0.26 KN/m

iii) Weight of fastenings per m of track = 0.28 KN/m

iv) Weight of sleeper(volume*density) =

$$\frac{0.25 \times 0.15 \times 2.8}{0.4} \times 7.4 = 1.94 \text{kN/m}$$

Total dead load per track = 3.62 KN/m

Total dead load per each rail = $\frac{3.62}{2}$ KN/m

= 1.81 KN/m

∴ Hence dead load = 1.81 KN/m.

Live load calculation:

The live load on bridge basically consists of the loads of the vehicles (train engines and coaches) that cross the bridge. The live load due to train loadings have been specified in "bridge rules" published by the railway board, ministry of railways for various types of tracks that is broad gauge, meter gauge and narrow gauges.

Impact Allowance:

The Indian railways designate the impact factor as coefficient of dynamic augment (CDA). Indian rail ways has specified CDA on the basis of extensive tests, and is applicable for speeds up to 160kmh on broad gauge and 100kmph on meter gauge. Its value is obtained by following expression.

1) For single track span the CDA as follows

$$\text{CDA} = [0.15 + \frac{8}{6+L}]$$

Where,

L = Total length of the span

$$\text{CDA} = 0.15 + \frac{8}{6+39}$$

$$= 0.32$$

Then take coefficient of dynamic augment as 30%

∴ Hence CDA = 30 %

Wind load calculation:

The bridge structure and the moving load on it cause obstruction in the flow of wind, and consequently wind loads, which are basically the lateral loads, are caused on the bridge structure. The basic wind pressure acting against the exposed area depends upon wind velocity, which in turn depends upon the height of the structure above the mean retarding surface and several other factors as per IS : 875 -1987.

Design of compression members:

The following are the recommendation based on (i) IS: 1915-1961, (ii) railway bridge code, and (iii) IRC: 24 – 1967.

General requirements:

1. The properties of the cross section shall be computed from the effective sectional area. When plates are provided solely for the purpose of lacing or battening, they shall be ignored in computing the radius of gyration of the section.
2. The effective sectional area shall be the gross area less the specified deductions for excessive width of plates and maximum deductions for open holes, including holes for pins and black bolts occurring in section perpendicular to the axis of the member.
3. The ratio of effective length to the least radius of gyration shall not exceed 120 for main members and 140 for wind bracing and subsidiary members.
4. The unsupported width of plate forming any part of compression members, measured between adjacent lines of rivets, bolts or welds connecting the plate to other parts of the section, unless effectively stiffened.
5. The open sides of built-up compression members of U or I sections shall be connected by lacing, battening or perforated plates where the length of the out stand towards the open side exceeds 16 times the mean thickness of the outstand.
6. Lacing, battening and perforated plates shall be designed as per code recommendations, and shall be proportioned to resist a total transverse shear force Q at any point in the length of the member equal to at least 2.5% of total axial force in the member together with all shear due to external forces, if, any, in the plane of lacing.

Compression members composed of two or more components, appropriately connected, may be designed as homogeneous members.

Effective Length of Compression Members:

In riveted, bolted or welded trusses, the compression members act in a complex fashion and effective length *l* shall be taken as given in table.

Member	In plane	Out Of Plane	
		Compression Chord Effectively Braced	Compression Chord Unraced
Chord members	*0.85 l*	*0.85 l*	*0.75l*
Diagonals members Single triangulated web system	*0.70l*	*0.85l*	*1.20l*
Vertical members Single triangulated web system	*0.70l*	*0.85l*	*1.20l*

Design of Tension members:

Tension members should preferably be of rigid cross-section, and when they composed of two or more components these shall be appropriately connected. The properties of the cross-section shall be computed from the effective sectional area.

For main members, the ratio of un supported length to the least radius of gyration shall not exceed 250 for railway bridges and 300 for road and foot bridges.

The opening sides of built-up tension members of U or I-section shall be connected by lacing, battening or perforated plates when the length of outstand, towards the open side, exceeds 16 times the mean thickness of the outstand. Lacing, battening and perforated plates shall be appropriately designed and shall be proportioned to resist all shear force due to external forces, if any, in the plate of lacing.

Tension members composed of angles, channels and I-sections. For this truss girder bridge tension members composed with double channels connected front to front and also I-sections for vertical members.

III. RESULTS AND DISCUSSION

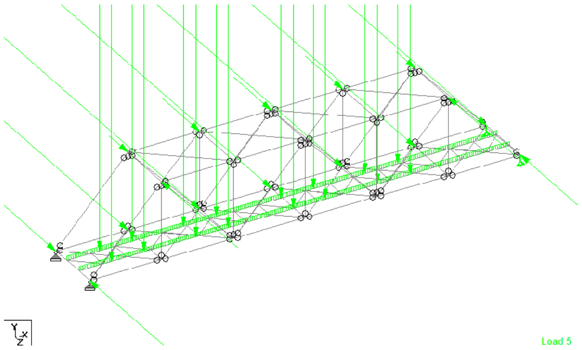

Figure 6. Bridge under full loading condition

COMPRESSION MEMBERS:

Results of Horizontal Compression Members:

Variation of Reliability index with reduction in cross sectional area of Member 2001:

Member 2001 is the top chord member which supports the load of super structure and transmit the same to bearings. The length of the member is 6.5 m. ISMC400 mm standard channel section is used for this member.

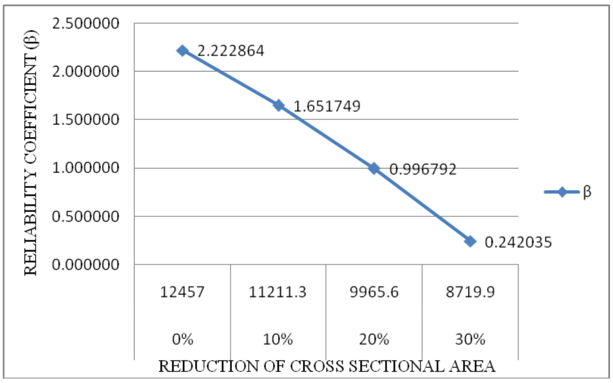

Figure 7. Variation of reliability with percentage reduction of section area in member 2001

Variation of Reliability index with reduction in cross sectional area of Member 2002:

Member 2002 is the top chord member which supports the load of super structure and transmit the same to bearings. The length of the member is 6.5 m. ISMC400 mm standard channel section is used for this member.

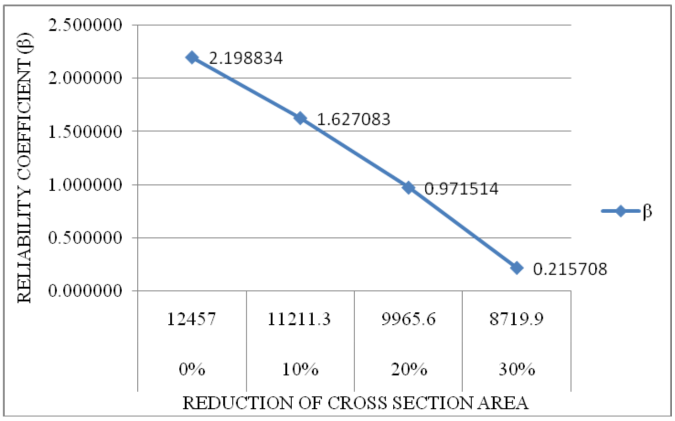

Figure 8. Variation of reliability with percentage reduction of section area in member 2002

Variation of Reliability index with reduction in cross sectional area of Member 2003:

Member 2003 is the top chord member which supports the load of super structure and transmit the same to bearings. The length of the member is 6.5 m. ISMC400 mm standard channel section is used for this member.

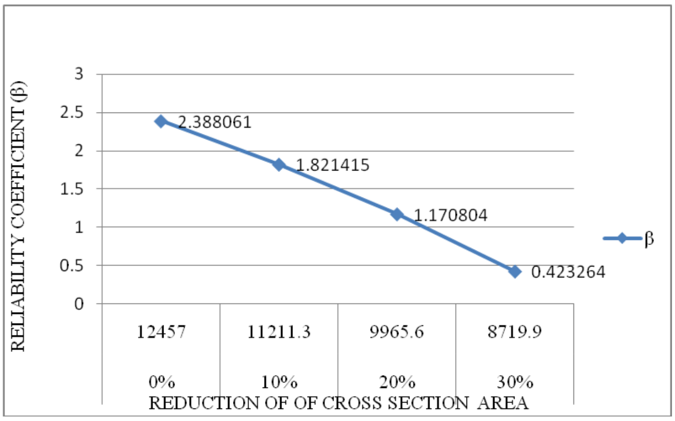

Figure 9. Variation of reliability with percentage reduction of section area in member 2003

Variation of Reliability index with reduction in cross sectional area of Member 2004:

Member 2004 is the top chord member which supports the load of super structure and transmit the same to bearings. The length of the member is 6.5 m. ISMC400 mm standard channel section is used for this member.

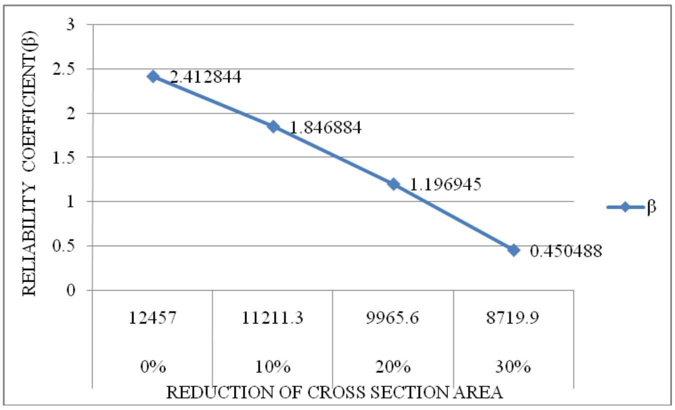

Figure 10. Variation of reliability with percentage reduction of section area in member 2004

Results of Diagonal Compression Members:

From STAAD Pro analysis the reliablity indices of the compression members 3001, 3003,3004 and 3006 pertaining to intact structue and with 10%, 20%, 30% reduction in cross sectional area are obtained. The results are discussed in susequent sections.

Variation of Reliability index with reduction in cross sectional area of Member 3001:

Member 3001 is the end post member. The length of the member is 9.55 m having channel section ISMC 400 mm. For this end post double channels of ISMC400 mm connected back to back and they are seperated by a distance of 380mm. The cross sectional area of the member is 12586 mm^2. In full load condition the member transfers 1752.161 kN in compression.

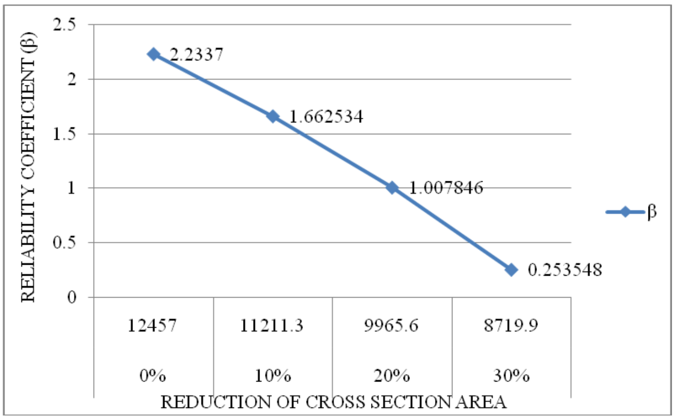

Figure 11. Variation of reliability with percentage reduction of section area in member 3001

Variation of Reliability index with reduction in cross sectional area of Member 3003:

Member 3003 is the intermediate diagonal member. The length of the member is 9.55 m having channel section ISLC250 mm. For this intermediate diagonal double channels of ISLC250 mm connected back to back and they are seperated by a distance of 280mm. The cross sectional area of the member is 7130 mm^2. In full load condition the member transfers 279.309kN in compression.

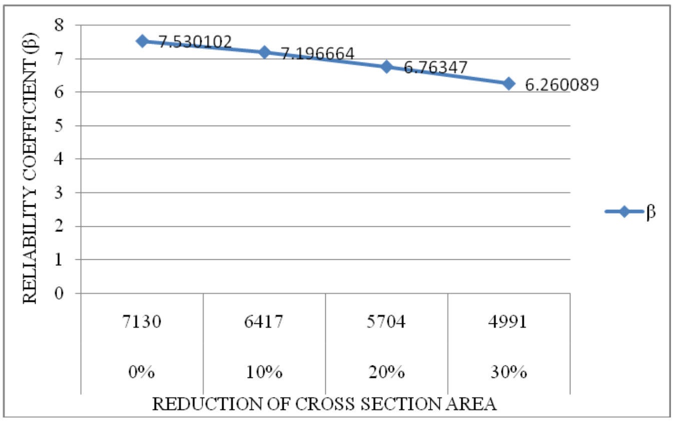

Figure 12. Variation of reliability with percentage reduction of section area in member 3003

Variation of Reliability index with reduction in cross sectional area of Member 3004:

Member 3004 is the intermediate diagonal member. The length of the member is 9.55 m having channel section ISLC250 mm. for this intermediate diagonal double channels of ISLC250 mm connected back to back and they are seperated by a distance of 280mm. The cross sectional area of the member is 7130 mm^2. In full load condition the member transfers 376.415 kN in compression.

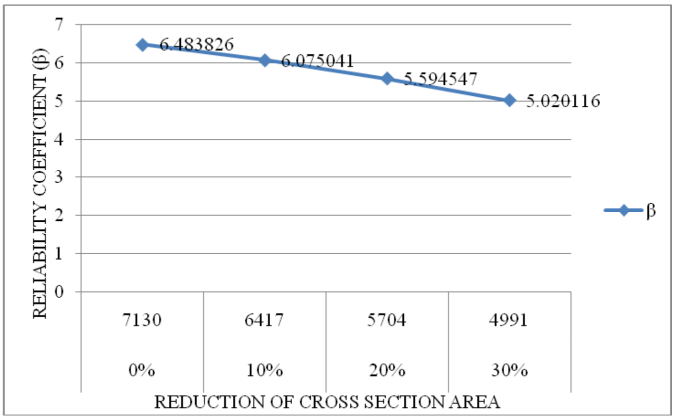

Figure 13. Variation of reliability with percentage reduction of section area in member 3004

Variation of Reliability index with reduction in cross sectional area of Member 3006:

Member 3006 is the end post member. The length of the member is 9.55 m having channel section ISMC400 mm. for this end post double channels of ISMC400 mm connected back to back and they are seperated by a distance of 380mm. The cross sectional area of the member is 12586 mm^2. In full load condition the member transfers 1532.635 kN in compression.

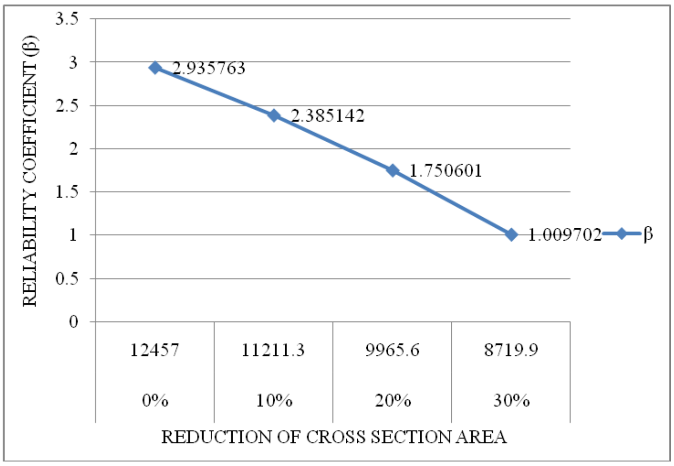

Figure 14. Variation of reliability with percentage reduction of section area in member 3006

Results of Vertical Compression Members:

From STAAD Pro analysis the reliablity indices of the compression members 4002 and 4004 pertaining to intact structue and with 10%, 20%, 30% reduction in cross sectional area are obtained. The results are discussed in susequent sections.

Variation of Reliability index with reduction in cross sectional area of Member 4002:

Member 4002 is the vertical member of bridge truss. The length of the member is 7.00 m having I-section ISLB300 mm. The cross sectional area of the member is 4808 mm^2. In full load condition the member transfers 14.314 kN in compression.

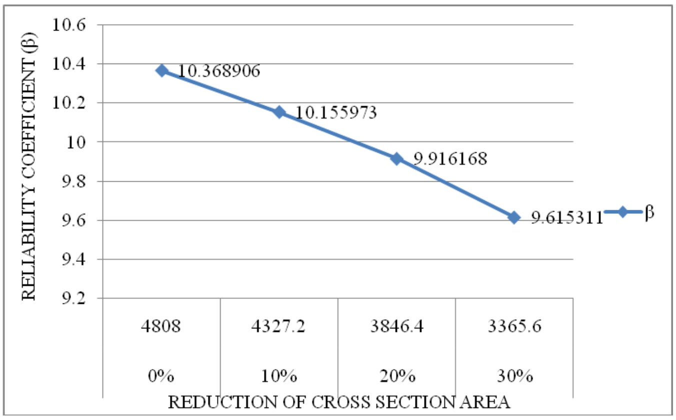

Figure 15. Variation of reliability with percentage reduction of section area in member 4002

Variation of Reliability index with reduction in cross sectional area of Member 4004:

Member 4004 is the vertical member of bridge truss. The length of the member is 7.00 m having I-section ISLB300 mm. The cross sectional area of the member is 4808 mm^2. In full load condition the member transfers 14.314 kN in compression.

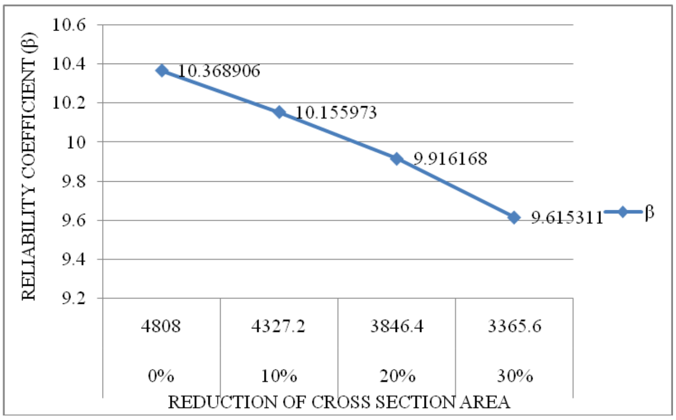

Figure 16. Variation of reliability with percentage reduction of section area in member 4004

Conclusion on reliability of compression memebers of the bridge truss:

In intact condition and with percentage reduction in area of cross section by 10, 20 and 30%. The member 2002 is having low reliability for all the reduction in cross sectional area compared to remaining members. That means member number 2002 is the most critical member which is having a probability to fail first among the horizontal compression members. Similarly top chord members 2001, 2003, and 2004 members having low reliability at 20% reduction. From the bar chart it is observed that the reduction in cross sectional area of reduces the reliability. The key horizntal member for prefornce of the bridge can be identified and role of other members can be asessed.

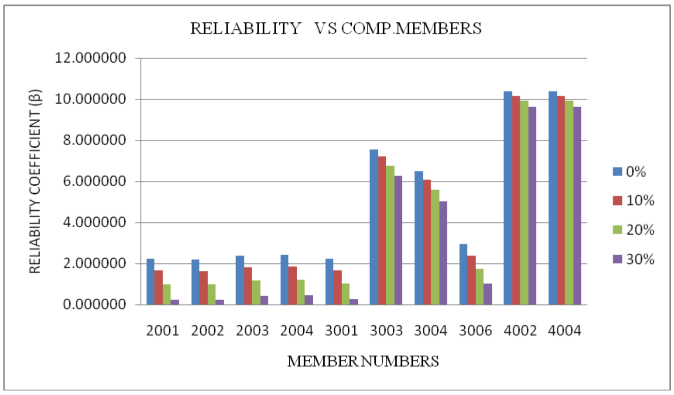

Figure 16. Present consolidated reliability indeces of all the compression members

TENSION MEMBERS:

Results of Horizontal Tension Members:

Variation of Reliability index with reduction in cross sectional area of Member 1001:

Member 1001 is the bottom chord member which supports the load of super structure and transmit the same to bearings. The length of the member is 6.5 m. ISMC350 mm standard channels section is used for this member. For this member double channels of ISMC350 mm connected frount to frount. The cross sectional area of this member is 10732 mm^2. In full load condition this member carry 989.302 kN in tension.

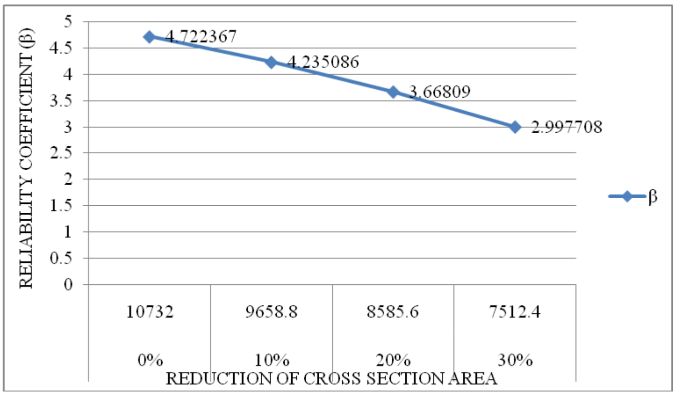

Figure 17. Variation of reliability with percentage reduction of section area in member 1001

Variation of Reliability index with reduction in cross sectional area of Member 1002:

Member 1002 is the bottom chord member which supports the load of super structure and transmit the same to bearings. The length of the member is 6.5 m. ISMC350 mm standard channels section is used for this member. For this member double channels of ISMC350 mm connected frount to frount. The cross sectional area of this member is 10732 mm^2. In full load condition this member carry 850.381 kN in tension.

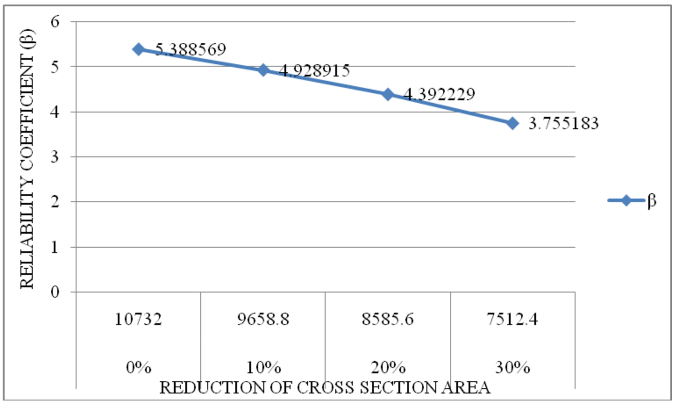

Figure 18. Variation of reliability with percentage reduction of section area in member 1002

Variation of Reliability index with reduction in cross sectional area of Member 1003:

Member 1003 is the bottom chord member which supports the load of super structure and transmit the same to bearings. The length of the member is 6.5 m. ISMC400 mm standard channels section is used for this member. For this member double channels of ISMC400 mm connected frount to frount. The cross sectional area of this member is 12586 mm^2. In full load condition this member carry 1606.57 kN in tension.

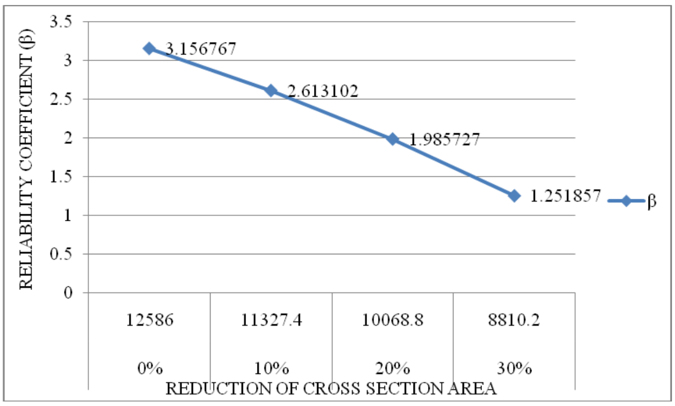

Figure 18. Variation of reliability with percentage reduction of section area in member 1003

Variation of Reliability index with reduction in cross sectional area of Member 1004:

Member 1004 is the bottom chord member which supports the load of super structure and transmit the same to bearings. The length of the member is 6.5 m. ISMC400 mm standard channels section is used for this member. For this member double channels of ISMC400 mm connected frount to frount. The cross sectional area of this member is 12586 mm^2. In full load condition this member carry 1607.14 kN in tension.

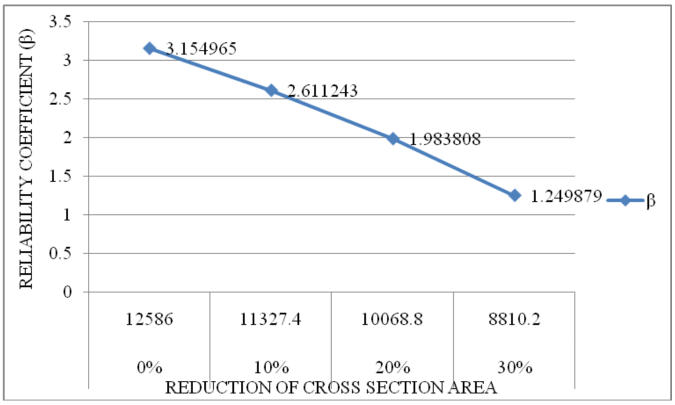

Figure 19. Variation of reliability with percentage reduction of section area in member 1004

Variation of Reliability index with reduction in cross sectional area of Member 1005:

Member 1005 is the bottom chord member which supports the load of super structure and transmit the same to bearings. The length of the member is 6.5 m. ISMC350 mm standard channels section is used for this member. For this member double channels of ISMC350 mm connected frount to frount. The cross sectional area of this member is 12586 mm^2. In full load condition this member carry 714.064 kN in tension.

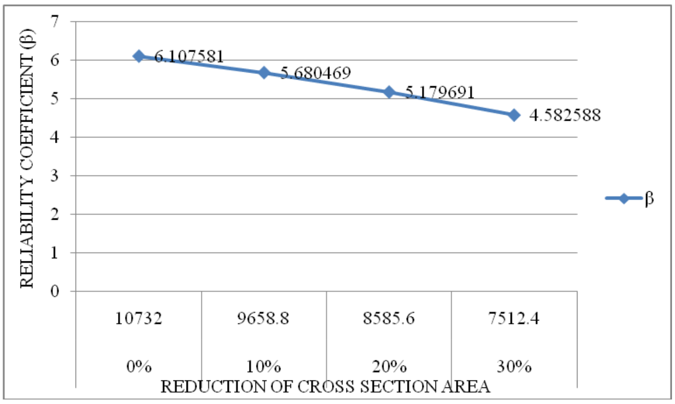

Figure 20. Variation of reliability with percentage reduction of section area in member 1005

Variation of Reliability index with reduction in cross sectional area of Member 1006:

Member 1006 is the bottom chord member which supports the load of super structure and transmit the same to bearings. The length of the member is 6.5 m. ISMC350 mm standard channels section is used for this member. For this member double channels of ISMC350 mm connected frount to frount. The cross sectional area of this member is 12586 mm^2. In full load condition this member carry 856.102 kN in tension.

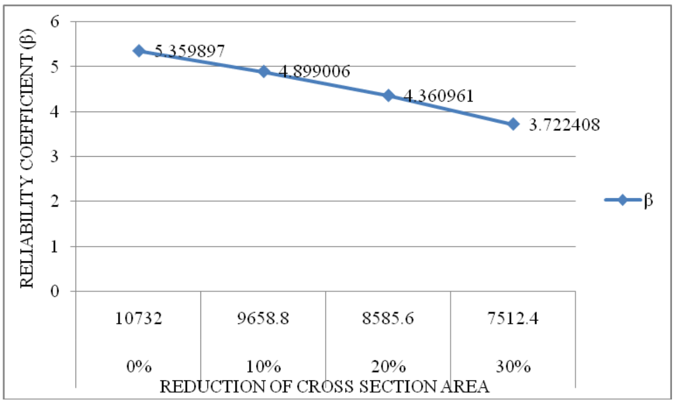

Figure 21. Variation of reliability with percentage reduction of section area in member 1006

Results of Diagonal Tension Members:

From STAAD Pro analysis the reliablity indices of the tension members 3002 and 3005 pertaining to intact structue and with 10%, 20%, 30% reduction in cross sectional area are obtained. The results are discussed in susequent sections.

Variation of Reliability index with reduction in cross sectional area of Member 3002:

Member 3002 is the internal diagonal member of truss. The length of the member is 9.55m. ISMC300 mm standard channels section is used for this member. For this member double channels of ISMC300 mm is connected frount to frount. The cross sectional area of this member is 9128 mm^2. In full load condition this member transfers 1014.7 kN in tension.

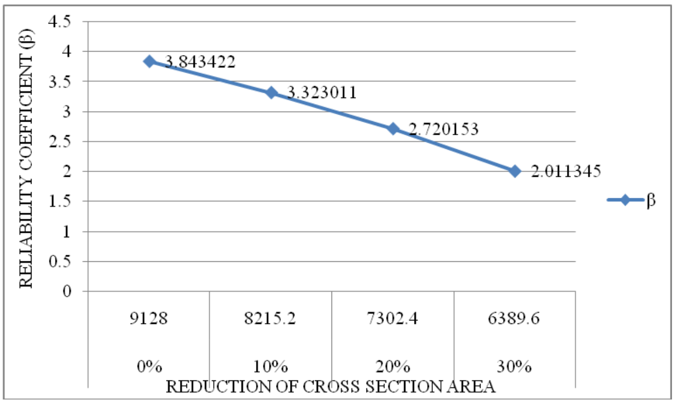

Figure 22. Variation of reliability with percentage reduction of section area in member 3002

Variation of Reliability index with reduction in cross sectional area of Member 3005:

Member 3005 is the internal diagonal member of truss. The length of the member is 9.55m. ISMC300 mm standard channels section is used for this member. For this member double channels of ISMC300 mm is connected frount to frount. The cross sectional area of this member is 9128 mm^2. In full load condition this member transfers 1137.12 kN in tension.

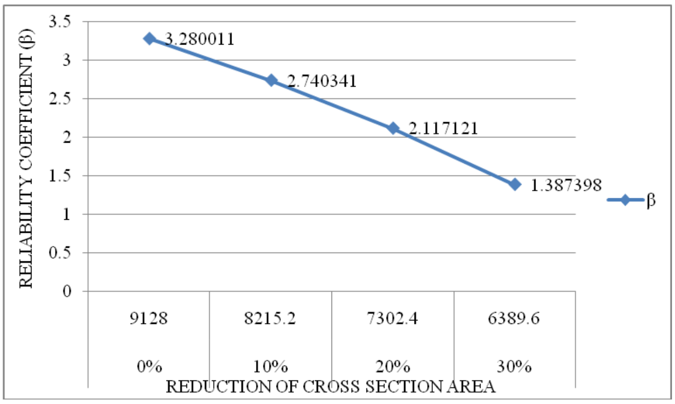

Figure 23. Variation of reliability with percentage reduction of section area in member 3005

Results of Vertical Tension Members:

From STAAD Pro analysis the reliablity indices of the tension members 4001,4003 and 4005 pertaining to intact structue and with 10%, 20%, 30% reduction in cross sectional area are obtained. The results are discussed in susequent sections.

Variation of Reliability index with reduction in cross sectional area of Member 4001:

Member 4001 is the vertical member of truss. The length of the member is 7.00 m having I-section ISLB300 mm. The cross sectional area of the member is 4808 mm^2. In full load condition the member transfers 524.827 kN in tension.

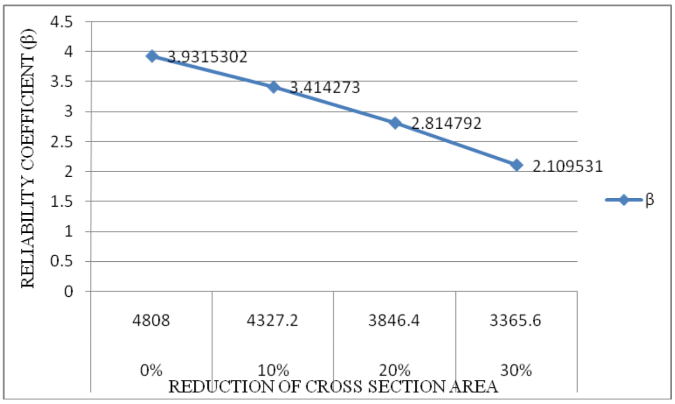

Figure 24. Variation of reliability with percentage reduction of section area in member 4001

Variation of Reliability index with reduction in cross sectional area of Member 4003:

Member 4003 is the vertical member of truss. The length of the member is 7.00 m having I-section ISLB300 mm. The cross sectional area of the member is 4808 mm^2. In full load condition the member transfers 460.942 kN in tension.

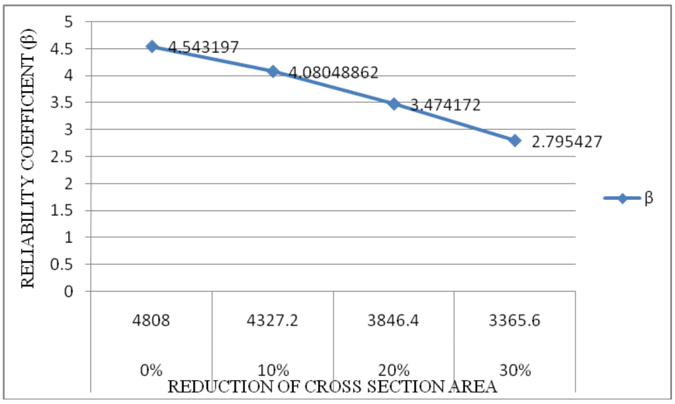

Figure 25. Variation of reliability with percentage reduction of section area in member 4003

Variation of Reliability index with reduction in cross sectional area of Member 4005:

Member 4005 is the vertical member of truss. The length of the member is 7.00 m having I-section ISLB300 mm. The cross sectional area of the member is 4808 mm^2. In full load condition the member transfers 274.252 kN in tension.

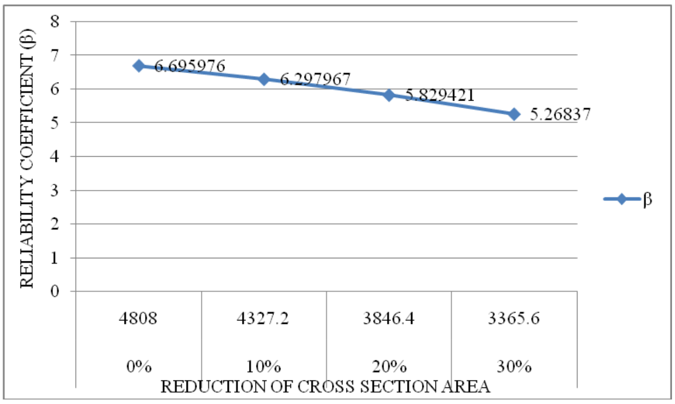

Figure 26. Variation of reliability with percentage reduction of section area in member 4005

Conclusion on reliability of tension memebers of the bridge truss:

In intact condition and with percentage reduction in area of cross section by 10, 20 and 30%. From the figure showen below the member 1003 & 1004 is having low reliability for all the reduction in cross sectional area compared to remaining members. That means member number 1003 & 1004 is the most critical member which is having a probability to fail first among the horizontal tension members. The internal diagonal member 3005 has low reliability at 30% reuction. From the bar chart it is observed that the reduction in cross sectional area of reduces the reliability. The key diagonal member for prefornce of the bridge can be identified and role of other members can be asessed.

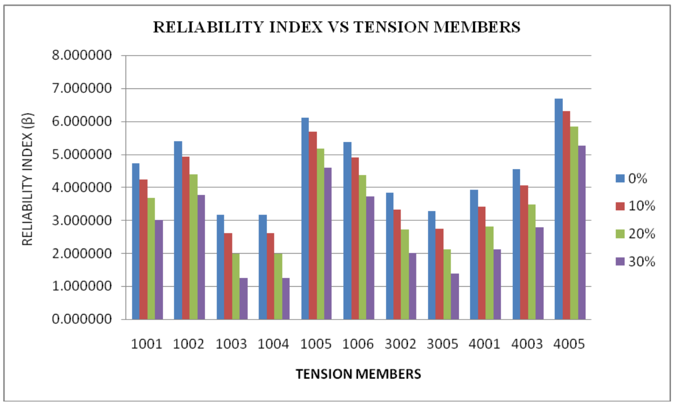

Figure 23. Present consolidated reliability indeces of all the tension members

IV. CONCLUSION

In this study of Reliability assessment of truss girder railway bridge four cases of the bridge is studied

- No reduction in cross section areas of members.
- Ten percent reduction in cross section areas of all primary and secondary members of all members of the truss girder railway bridge.
- Twenty percent reduction in cross section areas of all primary and secondary members of all members of the truss girder railway bridge.

Thirty percent reduction in cross section areas of all primary and secondary members of all members of the truss girder railway bridge.

V. REFERENCES

[1] Structural reliability analysis & design by R. Ranganathan.

[2] Design of steel structures by Dr. B. C. Punmia., Ashok Kumar Jain and Anil Kumar Jain.

[3] Aruz Petcherdchoo1, Luis A. C. Neves, and Dan M. Frangopol (2008) "Optimizing Lifetime Condition and Reliability of Deteriorating Structures with Emphasis on Bridges", Journal of Structural Engineering, Vol. 134, No.4.

[4] Brent Hall W (1988), "Reliability of service – proven structure" Journal of Structural Engineering, Vol. 114, No. 3.

[5] Dagher H. J., Q. Lu. Q. and A.H. Peyrot A. H. (1998), "Reliability of Transmission Structures including Nonlinear Effects" Journal of Structural Engineering. Vol. 124, No.8.

[6] Eidinger J. M. and Kempner L. "Reliability of Transmission Towers under Extreme Wind and Ice Loading" G&E Engineering Systems Inc. and Bonneville Power Administration.

[7] Gayatri Devi T., (2012) M.Tech. Dissertation Thesis titled "Reliability analysis of truss using MATLAB", submitted to Andhra University, Visakhapatnam.

[8] Lidvin Kjerengtraen and Paul H. Wirsching (1984) "Structural reliability analysis of series systems" Journal of Structural Engineering, Vol. 110, No. 7.

[9] Michael Havbro Faber (2009), "Basics of Structural Reliability" Swiss Federal Institute of Technology ETH, Zürich, Switzerland

[10] Alberto López López, Luis E. Pérez Rocha, David de León Escobedo, and Jorge Sánchez Sesma, (2009) " Reliability and Vulnerability Analysis of Electrical Substations and Transmission Towers for Definition of Wind and Seismic Damage Maps for Mexico", 11th American Conference on Wind Engineering – San Juan, Puero Rico June 22-26.