OPEN ACCESS
International Journal of Engineering and Advanced Technology (IJEAT)
ISSN: 2249-8958 (Online), Volume-8 Issue-6S3, September 2019

Reliability Analysis of Resultant Stress for Unsymmetrical Columns for Stress Follow Exponential Distribution

T. Sumathi Uma Maheswari, M. Tirumala Devi

Abstract:- ***When a body is subjected to eccentric loads, the direct stress as well as bending stress is produced. Resultant stress is obtained by adding these two stresses. In this paper, probabilistic approach has been made for designing the structure of unsymmetrical column by finding suitable parameters length of outer square and length of a hole and eccentric load of the column to get the specified reliability of the structure of a body or component. Reliability analysis has been done at the point of maximum compressive stress occurred and at the point of minimum tensile stress occurred. Reliability computations have been obtained for changing the various parameter values. It is observed from the computations that Reliability of the component when compressive stress occurs at the edge AB increases with increasing of length of outer square, decrease of load, decrease of length of hole and increasing of eccentricity. Reliability of the component when tensile stress occurs at the edge CD increases with decrease of length of outer square increasing the length of a hole, decreases the load and decrease of eccentricity.***

Keywords: ***Eccentric load, Direct stress, Bending stress, Reliability, Unsymmetrical section.***

I. INTRODUCTION

Failure of a system may occur due to certain types of stresses acting on them. If these stresses don't exceed a certain threshold value, they may work for a long period. Hence the stress occurred in the system plays a role for working the system. Several causes may lead to occurrence the stress like pressure, load, velocity, temperature etc.

In structural reliability there are several papers, which considered the stress dependent reliability problems. R.E Barlow and F. Proschan [1] studied Mathematical theory of reliability. Lorenzo Bardella [2] studied reliability of **I** order shear deformation models for sandwitch beams. R. Ranganathan[3] studied reliability analysis and design of structure. John Dalsgaard Sorensen [4] studied structural reliability theory and risk analysis. Micic.T, [5] studied Structural reliability applications. Hari Prasad and T. Sumathi Uma Maheswari et al [6] studied the reliability analysis of symmetrical column with eccentric loading from Lindley distribution. In this paper reliability analysis has been done for unsymmetrical columns with eccentric load.

Manuscript published on 30 September 2019.
***** Correspondence Author (s)
T.Sumathi Uma Maheswari, Department of Mathematics, Kakatiya University, Warangal, TS, Telangana, India.
M.Tirumala Devi, Department of Mathematics, Kakatiya University, Warangal, TS, Telangana, India.

II. STATISTICAL MODEL

Probability distribution of failure is defined as $F(t) = P[T \leq t], t \geq 0$

Reliability of a component is defined as the probability of successful working of a component for the given specified period under given environmental conditions[1]. i.e.,

$R(t) = P[T \geq t]\,, \quad t \geq 0 \quad t{:}\, given\ specified\ period$

If it works more than time t it may be considered as the component reliability is high then its probability distribution function of failure $F(t) = 1 - R(t)$

Probability density function is

$$f(x) = \frac{dF(x)}{dx}$$

Then hazard function is defined as

$$h(t) = \frac{f(t)}{R(t)}$$

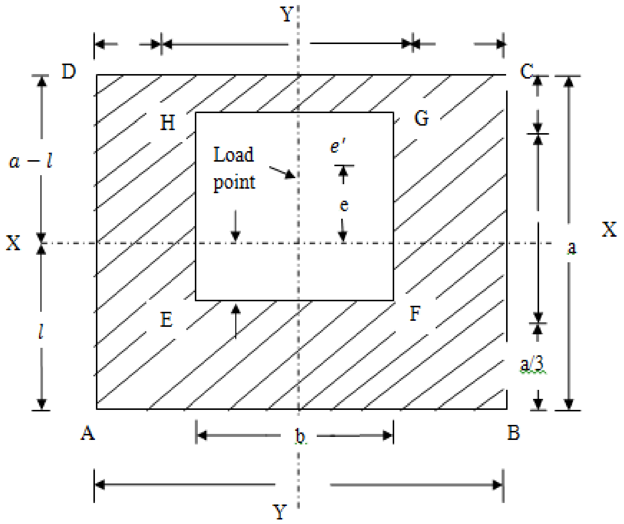
If $h(t) = \lambda$ (constant) then Probability density function of stress follows Exponential distribution with $f(x) = \lambda e^{-\lambda x}\ ,\lambda > 0, x \geq 0$

Stress dependent hazard model is given by [7]

$$z(t) = h(t)\sigma_1^{a_1}.\sigma_2^{a_2} \quad where\ \sigma_1, \sigma_2\ are\ stress\ ratio.$$
$$= \lambda\sigma$$

Then reliability of component

$$R(t) = e^{-\int_0^t z(t)dt}$$



A short column has a square section $(a \times a)mm^2$ with a square hole of $(b \times b)mm^2$ and it carrying the eccentric load P located as shown in the above figure.

In case of unsymmetrical columns which are subjected to eccentric loading, the centre of gravity (C.G) of the unsymmetrical section is to be determined, then the moment of inertia (MOI) of the section about axis passing through the CG is calculated. Next the distance between the corners of the section and its CG is to be determined. By using the values of the MOI and distance of the corners from the CG of two sections, the stresses on the corners are determined. Maximum compressive stress and tensile stresses are determined and then obtained the reliability of resultant stress on the two corners AB&CD

Let A be the area of the section

A_1 be the area of the outer square $= a^2$

A_2 be the area of the hole $= b^2$

$\bar{y}$ be the distance of C.G. of the section from AB

$$\bar{y} = \frac{A_1 y_1 + A_2 y_2}{A_1 + A_2} = l$$

Where

y_1 be the distance of C.G. of outer square from line $AB = \frac{a}{2}$

y_2 be the distance of C.G. of hole from line AB

Since the axis X-X lies at a distance $(\bar{y})$ from the line AB or at a distance outer length $(a - l)$.

since the load is unsymmetrical to X-X axis. Hence eccentricity at CG $e = \frac{a}{3} - l + b - e'$

Let P be the load applied on the section then

Moment about X-X axis $M = Pe$

Moment of inertia of outer square $ABCD$ about X-X axis.

$$\boldsymbol{I}_1 = (M.O.I.of\ ABCD\ about\ an\ axis\ parallel\ to\ X-X) + Area\ of\ ABCD(\ distance\ of\ CG\ of\ ABCD\ from\ X-X\ axis)^2$$

$$\boldsymbol{I}_2 = MOI\ of\ square\ hole\ about\ X-X\ axis$$

$$= (MOI\ of\ hole\ about\ CG) + Area\ of\ the\ whole(distance\ of\ hole\ from\ X-X\ axis)^2$$

$\boldsymbol{I}$ = Net MOI of the section about X-X axis $= \boldsymbol{I}_1 - \boldsymbol{I}_2$

Bending stress

$$\sigma_b = \frac{MY}{\boldsymbol{I}}$$

Y is maximum value of y from X-X axis.

Bending stress at the edge CD due to moment

$$\sigma_{b_1} = \frac{M(a-l)}{\boldsymbol{I}}$$

Bending stress at the edge AB due to moment

$$\sigma_{b_2} = \frac{Ml}{\boldsymbol{I}}$$

Resultant stress at the edge AB (max stress) $\sigma_1 = \sigma_0 + \sigma_{b_1}$

Resultant stress at the edge CD (min stress) $\sigma_2 = \sigma_0 - \sigma_{b_2}$

Reliability of the component when compressive stress occurs at the edge $ABR_1 = e^{-\lambda \sigma_1 t}$

Reliability of the component when tensile stress occurs at the edge CD $R_2 = e^{-\lambda \sigma_2 t}$

III. NUMERICAL RESULTS

Case(i): Changing the parameter a (length of outer square)
b=150, e'=50, P=200000, $\lambda = 0.001$, t=100

a	A	l	$\boldsymbol{I}$	σ_0	σ_{b_1}	σ_{b_2}	R_1	R_2
300	67500	141.6667	614062500	2.962963	3.008199	2.691547	0.550397	0.973223
310	73600	147.8668	711418428	2.717391	2.528176	2.305719	0.591818	0.959669
320	79900	153.8986	818088912	2.503129	2.142761	1.985341	0.628393	0.949539
330	86400	159.7917	934736250	2.314815	1.828511	1.716607	0.660781	0.941933
340	93100	165.5693	1.062E+09	2.148228	1.568971	1.489264	0.689547	0.936228
350	100000	171.25	1.201E+09	2	1.352275	1.295536	0.715175	0.931978
360	107100	176.8487	1.351E+09	1.867414	1.169662	1.129412	0.738077	0.928857
370	114400	182.3776	1.515E+09	1.748252	1.014533	0.986173	0.758602	0.926624
380	121900	187.8466	1.692E+09	1.640689	0.881832	0.862067	0.777049	0.925092
390	129600	193.2639	1.883E+09	1.54321	0.767623	0.754075	0.793673	0.92412
400	137500	198.6364	2.089E+09	1.454545	0.6688	0.659741	0.808694	0.923596

Retrieval Number: F12340986S319/2019©BEIESP
DOI:10.35940/ijeat.F1234.0986S319
Journal Website: www.ijeat.org

Published By:
Blue Eyes Intelligence Engineering
and Sciences Publication (BEIESP)

Case(ii): Changing the parameter b (length of hole)
a=350, e'=50, P=200000, $\lambda = 0.001$, t=100

b	A	l	I	σ_0	σ_{b_1}	σ_{b_2}	R_1	R_2
50	120000	175.6944	1247164352	1.666667	-1.64996	-1.66311	0.998331	0.716786
60	118900	175.8579	1246463331	1.682086	-1.37449	-1.38803	0.969709	0.735642
70	117600	175.9722	1245741065	1.70068	-1.09818	-1.11045	0.941529	0.754943
80	116100	176.0106	1244837809	1.722653	-0.82027	-0.8298	0.913714	0.774726
90	114400	175.9441	1243511375	1.748252	-0.53966	-0.54551	0.886158	0.795029
100	112500	175.7407	1241431327	1.777778	-0.25474	-0.25691	0.858728	0.815896
110	110400	175.3653	1238170820	1.811594	0.036709	0.036862	0.831245	0.837383
120	108100	174.778	1233195505	1.850139	0.337847	0.336991	0.803484	0.859577
130	105600	173.9331	1225848683	1.893939	0.653039	0.645124	0.775151	0.882601
140	102900	172.7778	1215331574	1.943635	0.98835	0.963564	0.745874	0.906642
150	100000	171.25	1200677083	2	1.352275	1.295536	0.715175	0.931978

Case(iii): Changing the parameter P (eccentric load on a section)
a=350, b=100, e'=50, $\lambda = 0.001$, t=100

P	A	l	I	σ_0	σ_{b_1}	σ_{b_2}	R_1	R_2
100000	112500	175.7407	1241431327	0.888889	-0.12737	-0.12846	0.926676	0.903269
120000	112500	175.7407	1241431327	1.066667	-0.15285	-0.15415	0.912669	0.885076
140000	112500	175.7407	1241431327	1.244444	-0.17832	-0.17984	0.898874	0.86725
160000	112500	175.7407	1241431327	1.422222	-0.2038	-0.20553	0.885288	0.849782
180000	112500	175.7407	1241431327	1.6	-0.22927	-0.23122	0.871907	0.832667
200000	112500	175.7407	1241431327	1.777778	-0.25474	-0.25691	0.858728	0.815896
220000	112500	175.7407	1241431327	1.955556	-0.28022	-0.2826	0.845748	0.799462
240000	112500	175.7407	1241431327	2.133333	-0.30569	-0.30829	0.832965	0.78336
260000	112500	175.7407	1241431327	2.311111	-0.33117	-0.33398	0.820375	0.767582
280000	112500	175.7407	1241431327	2.488889	-0.35664	-0.35967	0.807975	0.752122
300000	112500	175.7407	1241431327	2.666667	-0.38212	-0.38537	0.795762	0.736974

Case(iv): Changing the parameter e' (eccentricity)
a=350, b=100, P=200000, $\lambda = 0.001$, t=100

e'	A	l	I	σ_0	σ_{b_1}	σ_{b_2}	R_1	R_2
10	112500	175.7407	1241431327	1.777778	0.868212	0.875593	0.767514	0.913732
13	112500	175.7407	1241431327	1.777778	0.78399	0.790656	0.774005	0.906003
16	112500	175.7407	1241431327	1.777778	0.699769	0.705718	0.780551	0.898341
19	112500	175.7407	1241431327	1.777778	0.615547	0.62078	0.787153	0.890743
22	112500	175.7407	1241431327	1.777778	0.531325	0.535842	0.793811	0.883209
25	112500	175.7407	1241431327	1.777778	0.447103	0.450904	0.800525	0.875739
28	112500	175.7407	1241431327	1.777778	0.362881	0.365967	0.807295	0.868332
31	112500	175.7407	1241431327	1.777778	0.27866	0.281029	0.814123	0.860988
34	112500	175.7407	1241431327	1.777778	0.194438	0.196091	0.821009	0.853706
37	112500	175.7407	1241431327	1.777778	0.110216	0.111153	0.827953	0.846485
40	112500	175.7407	1241431327	1.777778	0.025994	0.026215	0.834955	0.839326

IV. CONCLUSION:

Reliability analysis of unsymmetrical columns subjected to eccentric load for stress follow exponential distribution has been obtained. It is observed from the computations that Reliability $(R_1)$of the component when compressive stress occurs at the edge *AB* increases with increasing of length of outer square (a), decrease of load(P), decrease of length of hole(b) and increasing of eccentricity$(\boldsymbol{e}')$. Reliability(R_2) of the component when tensile stress occurs at the edge *CD* increases with decrease of length of outer square(a), increasing the length of a hole(b), decreases the load(P) and decrease of eccentricity$(\boldsymbol{e}')$.

REFERENCES

1. Barlow R.E., and Proschan. F, "Mathematical Theory of Reliability", Wiley, New York, 1965.
2. Lorenzo Bardella, "Reliability study of I order shear deformation models for sandwitch beams", Journal of Mechanics of Materials and structures, vol.3, No.7, 2008.
3. Ranganathan.R, "Reliability analysis and Design of structures", Tata McGraw-Hill Publishing company limited, New Delhi.
4. John Dalsgaard Sorensen, " A notes on structural reliability theory and risk analysis", 2004.
5. Micic.T, " Structural reliability applications" Faculty of Civil Engineering and Architecture, University of Nis, Serbia,2012.
6. Hari Prasad, T. Sumathi Uma Maheswari and Shirisha, "The reliability analysis of symmetrical column with eccentric loading from Lindley distribution", Communication in Maths and Statistics, Springer, 2019.
7. Balaguruswamy. E, "Reliability Engineering", Tata McGraw-Hill Publishing company limited, New Delhi.

Retrieval Number: F12340986S319/2019©BEIESP
DOI:10.35940/ijeat.F1234.0986S319
Journal Website: www.ijeat.org

Published By:
Blue Eyes Intelligence Engineering
and Sciences Publication (BEIESP)