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Case Study of Cascade Reliability with weibull Distribution

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***Abstract*—This paper endeavors to present reliability of an n-cascade system, whose stress and strength distributions are Weibull. Expressions for the system reliability are obtained when the stress and strength distributions are weibull. Reliability values for a cascade system with weibull distribution are computed and are presented graphically.**

***Index Terms*— Cascade Reliability, Weibull Distribution, Stress- Strength Model, Probability Density Function**

I. INTRODUCTION

If X denotes the strength of a component and Y is the stress imposed on it. The component operates as long as Y is less than X and the Reliability of the component may therefore be defined as

$R_c = P(X>Y)$

The probability of the failure of a system depends upon the stresses and strengths of the system. If the stress exceeds the strength, the system fails which has been considered by Kapur and Lamberson [1].The reliability of n-Cascade system with stress attenuation has been considered by Pandit and Srivastav [2] ,whereas Raghava Char [3] studied the concept of cascade system reliability when both with stress and strength follow identical distributions. A.Rekha and T.Shyam Sundar [4] studied similar stress attenuation studies with stress and strength following Gamma and Exponential distribution.Rekha and Chenchu Raju [5] studied the same by considering Rayleigh distribution for the strength and stress with certain attenuation factors.

II.GENERAL MATHEMATICAL MODEL

Let $X_1, X_2, X_3, \ldots X_n$ be the strength of the component $C_1, C_2, C_3, \ldots C_n$ are arranged in order of activation. All the X_i's are independently and identically distributed random variables with Probability density function $f_i(x_i)$, (i = 1, 2, 3, ... n). Also let Y_1 be the stress on the first component which is also randomly distributed with the density function $g(Y_1)$.

If $Y_1 < X_1$, the first component C_1 works and the system survives and if $Y_1 > X_1$ leads to the failure of the component C_1. Then the second component C_2 in the line takes its place with strength X_2. However, the stress Y_2 on C_2 will be different from Y_1. Let $Y_2 = k_2^* Y_1$, where $k_2^* = K_1 K_2$ is the cumulative attenuation factor. By definition $K_1=1$. In general, if the (n-1)th component fails, the nth component with strength X_n get activated and will be subjected to the stress.

$$Y_n = K_n Y_{n-1} = k_n^* Y_1$$

The reliability R (n) of the system to survive with the first (n-1) components failed and the nth component active is given by

$$R(n) = P\left[\left\{\bigcap_{i=1}^{n-1}(x_i \le y_i)\right\}\bigcap(x_n \ge y_n)\right] \quad (1)$$

$$= p\left[x_1 < k_1^* y_1, x_2 < k_2^* y_1, \quad x_3 < k_3^* y_1 \ldots \right.$$

$$\left. \ldots x_{n-1}^* < k_{n-1}^* y_1 \quad and \quad x_n \ge k_n^* y_1 \right] \quad (2)$$

$$= \int_{-\infty}^{\infty}\left[\int_{-\infty}^{k_1^* y_1}\int_{-\infty}^{k_2^* y_1}\ldots\int_{-\infty}^{k_{n-2}^* y_1}\int_{-\infty}^{k_{n-1}^* y_1}\int_{k_n^* y_1}^{\infty} f_n(x_n)dx_n \ldots f(x_1)dx_1\right]g(y_1)dy_1$$

(3)

$$= \int_{-\infty}^{\infty}\left[\int_{-\infty}^{k_1^* y_1} f(x_1)dx_1 \int_{-\infty}^{k_2^* y_1} f(x_2)dx_2 \ldots\ldots \int_{-\infty}^{k_{n-2}^* y_1} f(x_{n-2})dx_{n-2}\right.$$

$$\left.\int_{-\infty}^{k_{n-1}^* y_1} f(x_{n-1})dx_{n-1} \int_{k_n^* y_1}^{\infty} f(x_n)dx_n\right] g(y_1)dy_1 \quad (4)$$

R(n)=

$$\int_{-\infty}^{\infty}\left[F_1(K_1^* y_1)F_2(K_2^* y_1)\ldots\ldots F_{n-1}(K_{n-1}^* y_1)\overline{F}_n(K_n^* y_1)\right]g((y_1)dy_1$$

(5)

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The reliability of n-cascade system is given by

$$R_n = \sum_{i=1}^{n} R(i)$$

The above formula enables to compute the reliability of an n-cascade system for any specified distribution.

WHEN STRESS-STRENGTH ARE WEIBULL

Let us suppose that X_i, i = 1, 2, 3 ... n is a weibull variate with density function

$$f_i(x_i) = \lambda_i \, \alpha \; x_i^{\alpha-1} e^{-\lambda_i x_i^{\alpha}} \qquad (6)$$

and Y_1 is also a weibull variate with density function

$$g(y_1) = \mu\alpha \; y_1^{\alpha-1} e^{-\mu Y_1^{\alpha}} \;, \; y_1 > 0 \qquad (7)$$

Here shape parameter α is same for all the distribution only the scale parameter λ_i is changing from distribution to distribution. Then

$$R(i) = \int_{\circ}^{\infty} \Big[\Big\{ 1 - e^{-\lambda_1 y_1^{\alpha}} \Big\} \Big\{ 1 - e^{-\lambda_2 y_1^{\alpha}} \Big\} .....$$

$$....... \Big\{ 1 - e^{-\lambda_{i-1} k^{*}_{i-2} y_1^{\alpha}} \Big\} e^{-\lambda_1 k_{i-1} y_i^{\alpha}} \Big] g(y_1) dy_1$$

$$= \int_{\circ}^{\infty} \Big[1 - \sum_{j-1}^{i-1} e^{b_j y_1^{\alpha}} + \sum_{j<p=1}^{i-1} e^{-(b_j + b_p) y_1^{\alpha}} + ...$$

$$...(-1)^{i-1} e^{-(b_1 + b_2 + ... + b_{i-1}) y_1^{\alpha}} \Big] e^{-b_i y_1^{\alpha}} g(y_1) dy_1$$

(8)

Where $b_u = \lambda_u \, k^{*}_{u-1}$, $k^{*}_{o} = 1$

$$\text{Now} \int_{\circ}^{\infty} e^{-p y_1^{\alpha}} g(y_1) dy_1 = \int_{\circ}^{\infty} e^{-p y_1^{\alpha}} \alpha \cdot \mu \cdot y_1^{\alpha-1} \cdot e^{-\mu y_1^{\alpha}} dy_1$$

$$= \frac{\mu}{p+\mu} \qquad (9)$$

A.CASE STUDY

Let $\boxed{}$ or $b_i = e_i \mu$

R(i)=

$$\left[\frac{1}{1+\ell_i} - \sum_{j=1}^{i-1} \frac{1}{1+\ell_i+\ell_j} + \sum_{j<p=1}^{i-1} \frac{1}{1+\ell_i+\ell_j+\ell_p} + ... \right.$$

$$\left. ....+(-1)^{i-1} \frac{1}{1+\ell_1+\ell_2+......\ell_i} \right] \qquad (10)$$

Taking i =1, 2, 3, 4 we get

$$R(1) = \frac{1}{1+\ell_1}$$

$$R(2) = \left[\frac{1}{1+\ell_2} - \frac{1}{1+\ell_2+\ell_1} \right]$$

R(3)=

$$\left[\frac{1}{1+\ell_3} - \frac{1}{1+\ell_3+\ell_1} - \frac{1}{1+\ell_3+\ell_2} + \frac{1}{1+\ell_1+\ell_2+\ell_3} \right]$$

R(4)=

$$\left[\frac{1}{1+\ell_4} - \frac{1}{1+\ell_4+\ell_3} - \frac{1}{1+\ell_4+\ell_2} - \frac{1}{1+\ell_4+\ell_1} \right.$$

$$+ \frac{1}{1+\ell_4+\ell_1+\ell_2} + \frac{1}{1+\ell_4+\ell_1+\ell_3} + \frac{1}{1+\ell_4+\ell_2+\ell_3}$$

$$\left. - \frac{1}{1+\ell_1+\ell_2+\ell_3+\ell_4} \right]$$

***Case 1*:-** When $\ell_i = i\ell$

$$R(1) = \frac{1}{1+\ell}$$

$$R(2) = \left[\frac{1}{1+2\ell} - \frac{1}{1+3\ell} \right]$$

$$R(3) = \left[\frac{1}{1+3\ell} - \frac{1}{1+4\ell} - \frac{1}{1+5\ell} + \frac{1}{1+6\ell} \right]$$

R(4)=

$$\left[\frac{1}{1+4\ell} - \frac{1}{1+10\ell} - \frac{1}{1+6\ell} - \frac{1}{1+5\ell} + \frac{1}{1+8\ell} + \frac{1}{1+9\ell} \right]$$

***Case 2*:-** When $\ell_i = \ell$

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R (1) = $\dfrac{1}{1+\ell}$

(R (1) = $\dfrac{1}{1+\ell}$

R (2) = $\left[\dfrac{1}{1+\ell}-\dfrac{1}{1+2\ell}\right]$

R (3) = $\left[\dfrac{1}{1+\ell}-\dfrac{2}{1+2\ell}+\dfrac{1}{1+3\ell}\right]$

R (4) = $\left[\dfrac{1}{1+\ell}-\dfrac{3}{1+2\ell}+\dfrac{3}{1+3\ell}-\dfrac{1}{1+4\ell}\right]$

Case 3:- When $\ell_i = i!\ell$

R (1) = $\dfrac{1}{1+\ell}$

R (2) = $\left[\dfrac{1}{1+2\ell}-\dfrac{1}{1+3\ell}\right]$

R (3) = $\left[\dfrac{1}{1+6\ell}-\dfrac{1}{1+7\ell}-\dfrac{1}{1+8\ell}+\dfrac{1}{1+9\ell}\right]$

$$R(4) = \left[\frac{1}{1+24\ell}-\frac{1}{1+30\ell}-\frac{1}{1+26\ell}-\frac{1}{1+25\ell}\right.$$
$$\left.+\frac{1}{1+27\ell}+\frac{1}{1+31\ell}+\frac{1}{1+32\ell}-\frac{1}{1+33\ell}\right]$$

Case 4:- When $\ell_i = (i+1)!\ell$

R (1) = $\dfrac{1}{1+2\ell}$

R (2) = $\left[\dfrac{1}{1+6\ell}-\dfrac{1}{1+8\ell}\right]$

R (3) = $\left[\dfrac{1}{1+24\ell}-\dfrac{1}{1+26\ell}-\dfrac{1}{1+30\ell}+\dfrac{1}{1+32\ell}\right]$

$$R(4) = \left[\frac{1}{1+120\ell}-\frac{1}{1+144\ell}-\frac{1}{1+126\ell}-\frac{1}{1+122\ell}\right.$$
$$\left.+\frac{1}{1+128\ell}+\frac{1}{1+146\ell}+\frac{1}{1+150\ell}-\frac{1}{1+152\ell}\right]$$

Case 5:- When $\ell_i = (i-1)!\ell$

R (1) = $\dfrac{1}{1+\ell}$

R (2) = $\left[\dfrac{1}{1+\ell}-\dfrac{1}{1+2\ell}\right]$

R (3) = $\left[\dfrac{1}{1+2\ell}-\dfrac{2}{1+3\ell}+\dfrac{1}{1+4\ell}\right]$

R (4) = $\left[\dfrac{1}{1+6\ell}-\dfrac{2}{1+9\ell}+\dfrac{2}{1+7\ell}-\dfrac{1}{1+10\ell}\right]$

Case 6:- When $\ell_i = \ell/i!$

R (1) = $\dfrac{1}{1+\ell}$

R (2) = $\left[\dfrac{2}{2+\ell}-\dfrac{2}{2+3\ell}\right]$

R (3) = $\left[\dfrac{6}{6+\ell}-\dfrac{6}{6+7\ell}-\dfrac{6}{6+4\ell}+\dfrac{6}{6+10\ell}\right]$

$$R(4) = \left[\frac{24}{24+\ell}-\frac{24}{24+5\ell}-\frac{24}{24+5\ell}-\frac{24}{24+13\ell}+\frac{24}{24+25\ell}\right.$$
$$\left.+\frac{24}{24+37\ell}+\frac{24}{24+29\ell}+\frac{24}{24+17\ell}-\frac{24}{24+41\ell}\right]$$

Case 7:- When $\ell_i = \ell/(i+1)!$

R (1) = $\dfrac{2}{2+\ell}$

R (2) = $\left[\dfrac{6}{6+\ell}-\dfrac{6}{6+4\ell}\right]$

R (3) = $\left[\dfrac{24}{24+\ell}-\dfrac{24}{24+13\ell}-\dfrac{24}{24+5\ell}+\dfrac{24}{24+17\ell}\right]$

$$R(4) = \left[\frac{120}{120+\ell}-\frac{120}{120+6\ell}-\frac{120}{120+21\ell}-\frac{120}{120+61\ell}\right.$$
$$\left.+\frac{120}{120+81\ell}+\frac{120}{120+66\ell}+\frac{120}{120+26\ell}-\frac{120}{120+86\ell}\right]$$

Case 8:- When $\ell_i = \ell/(i-1)!$

R (1) = $\dfrac{1}{1+\ell}$

R (2) = $\left[\dfrac{1}{1+\ell}-\dfrac{1}{1+2\ell}\right]$

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R (3) = $\left[\frac{2}{2+\ell}-\frac{4}{2+3\ell}+\frac{2}{2+5\ell}\right]$

R(4)=
$\left[\frac{6}{6+\ell}-\frac{6}{6+4\ell}-\frac{12}{6+7\ell}+\frac{6}{6+13\ell}+\frac{12}{6+10\ell}-\frac{6}{6+16\ell}\right]$

TABLE I: When $\ell_i = i\ell$

ρ	R1	R2	R3	R4	SR2	SR3	SR4
0.00	1.0000	0.0000	0.0000	0.0000	1.0000	1.0000	1.0000
0.40	0.7143	0.1010	0.0307	0.0127	0.8153	0.8460	0.8587
0.50	0.6667	0.1000	0.0310	0.0128	0.7667	0.7976	0.8104
0.70	0.5882	0.0941	0.0295	0.0121	0.6823	0.7118	0.7240
0.90	0.5263	0.0869	0.0273	0.0112	0.6132	0.6405	0.6517
1.00	0.5000	0.0833	0.0262	0.0107	0.5833	0.6095	0.6202
1.20	0.4545	0.0767	0.0241	0.0098	0.5313	0.5553	0.5651
1.40	0.4167	0.0709	0.0222	0.0090	0.4875	0.5097	0.5187
1.50	0.4000	0.0682	0.0213	0.0086	0.4682	0.4895	0.4981
1.70	0.3704	0.0633	0.0198	0.0079	0.4337	0.4535	0.4614
1.80	0.3571	0.0611	0.0190	0.0076	0.4183	0.4373	0.4450
1.90	0.3448	0.0591	0.0184	0.0074	0.4039	0.4223	0.4297
2.00	0.3333	0.0571	0.0178	0.0071	0.3905	0.4082	0.4154
2.10	0.3226	0.0553	0.0172	0.0069	0.3779	0.3951	0.4020
2.20	0.3125	0.0536	0.0166	0.0066	0.3661	0.3827	0.3894
2.30	0.3030	0.0520	0.0161	0.0064	0.3550	0.3711	0.3776
2.40	0.2941	0.0505	0.0156	0.0062	0.3446	0.3602	0.3664
2.50	0.2857	0.0490	0.0152	0.0060	0.3347	0.3499	0.3559
2.60	0.2778	0.0477	0.0147	0.0059	0.3254	0.3402	0.3460
2.70	0.2703	0.0464	0.0143	0.0057	0.3166	0.3309	0.3366

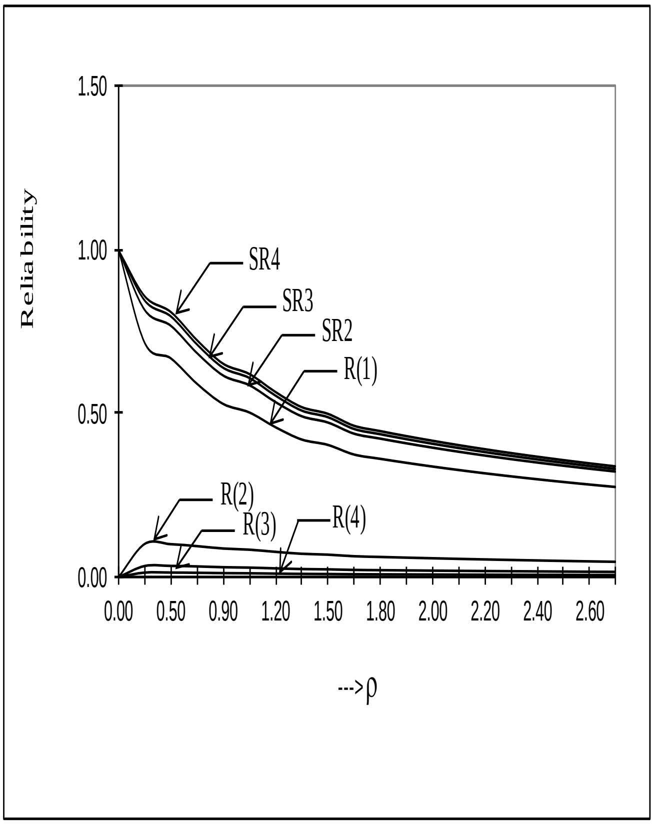

Fig 1: When $\ell_i = i\ell$

TABLE II: When $\ell_i = \ell$

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ρ	R1	R2	R3	R4	SR2	SR3	SR4
1.50	0.4000	0.1500	0.3818	0.0526	0.5500	0.9318	0.9844
1.75	0.3636	0.1414	0.3418	0.0520	0.5051	0.8469	0.8988
2.00	0.3333	0.1333	0.3095	0.0508	0.4667	0.7762	0.8270
2.25	0.3077	0.1259	0.2829	0.0493	0.4336	0.7164	0.7658
2.50	0.2857	0.1190	0.2605	0.0477	0.4048	0.6653	0.7130
2.75	0.2667	0.1128	0.2414	0.0461	0.3795	0.6209	0.6670
3.00	0.2500	0.1071	0.2250	0.0445	0.3571	0.5821	0.6266
3.25	0.2353	0.1020	0.2107	0.0429	0.3373	0.5479	0.5909
3.50	0.2222	0.0972	0.1981	0.0414	0.3194	0.5175	0.5589
3.75	0.2105	0.0929	0.1869	0.0400	0.3034	0.4903	0.5303
4.00	0.2000	0.0889	0.1769	0.0386	0.2889	0.4658	0.5044
4.25	0.1905	0.0852	0.1680	0.0373	0.2757	0.4437	0.4810
4.50	0.1818	0.0818	0.1599	0.0361	0.2636	0.4235	0.4596
4.75	0.1739	0.0787	0.1525	0.0349	0.2526	0.4051	0.4400
5.00	0.1667	0.0758	0.1458	0.0338	0.2424	0.3883	0.4221
5.25	0.1600	0.0730	0.1397	0.0328	0.2330	0.3727	0.4055
5.50	0.1538	0.0705	0.1341	0.0318	0.2244	0.3584	0.3902
5.75	0.1481	0.0681	0.1289	0.0309	0.2163	0.3452	0.3760
5.80	0.1471	0.0677	0.1279	0.0307	0.2148	0.3426	0.3733
6.00	0.1429	0.0659	0.1241	0.0300	0.2088	0.3329	0.3628

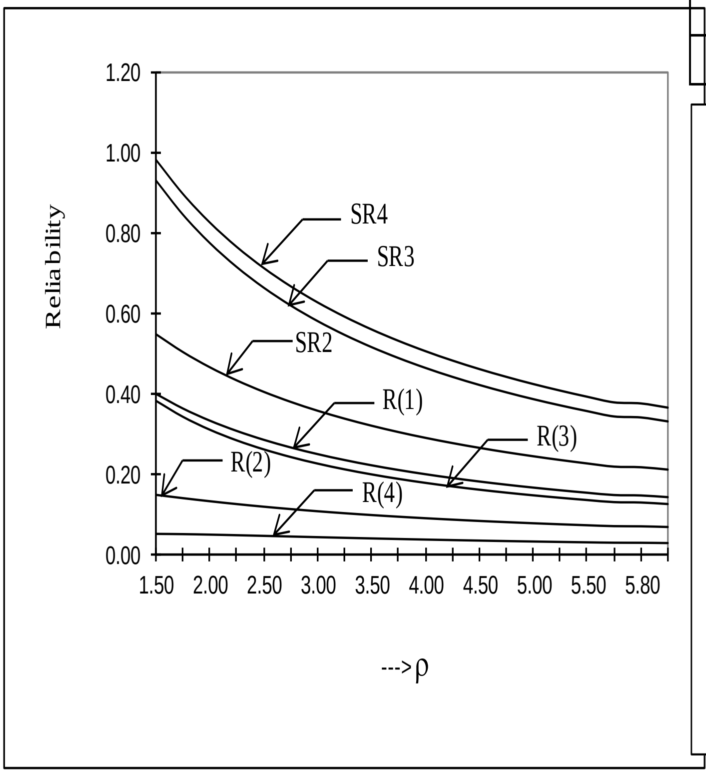

Fig 2: When $\ell_i = \ell$

TABLE III: When $\ell_i = i!\ell$

ρ	R1	R2	R3	R4	SR2	SR3	SR4
0.00	1.0000	0.0000	0.0000	0.0000	1.0000	1.0000	1.0000
0.25	0.8000	0.0952	0.0107	0.0003	0.8952	0.9060	0.9062
0.50	0.6667	0.1000	0.0096	0.0002	0.7667	0.7763	0.7764
0.75	0.5714	0.0923	0.0080	0.0001	0.6637	0.6717	0.6719
1.00	0.5000	0.0833	0.0067	0.0001	0.5833	0.5901	0.5902
1.25	0.4444	0.0752	0.0058	0.0001	0.5196	0.5254	0.5255
1.50	0.4000	0.0682	0.0051	0.0001	0.4682	0.4733	0.4733
1.75	0.3636	0.0622	0.0045	0.0001	0.4259	0.4304	0.4304
2.00	0.3333	0.0571	0.0041	0.0001	0.3905	0.3945	0.3946
2.25	0.3077	0.0528	0.0037	0.0000	0.3605	0.3642	0.3642
2.50	0.2857	0.0490	0.0034	0.0000	0.3347	0.3381	0.3382
2.75	0.2667	0.0457	0.0031	0.0000	0.3124	0.3155	0.3156
3.00	0.2500	0.0429	0.0029	0.0000	0.2929	0.2957	0.2958
3.25	0.2353	0.0403	0.0027	0.0000	0.2756	0.2783	0.2783
3.50	0.2222	0.0380	0.0025	0.0000	0.2603	0.2628	0.2628
3.75	0.2105	0.0360	0.0024	0.0000	0.2465	0.2489	0.2489
4.00	0.2000	0.0342	0.0022	0.0000	0.2342	0.2364	0.2365
4.25	0.1905	0.0325	0.0021	0.0000	0.2230	0.2251	0.2252
4.50	0.1818	0.0310	0.0020	0.0000	0.2129	0.2149	0.2149
4.75	0.1739	0.0297	0.0019	0.0000	0.2036	0.2055	0.2055

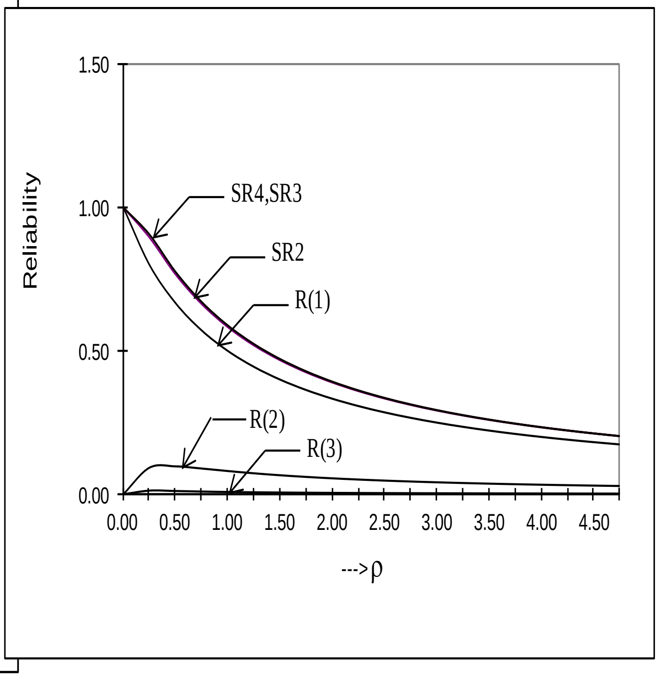

Fig 3: When $\ell_i = i!\ell$

TABLE IV: When $\ell_i = (i+1)!\ell$

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ρ	R1	R2	R3	R4	SR2	SR3	SR4
0.00	1.0000	0.0000	0.0000	0.0000	1.0000	1.0000	1.0000
0.25	0.6667	0.0667	0.0030	0.0000	0.7333	0.7363	0.7363
0.50	0.5000	0.0500	0.0018	0.0000	0.5500	0.5518	0.5518
0.75	0.4000	0.0390	0.0013	0.0000	0.4390	0.4403	0.4403
1.00	0.3333	0.0317	0.0010	0.0000	0.3651	0.3661	0.3661
1.25	0.2857	0.0267	0.0008	0.0000	0.3125	0.3133	0.3133
1.50	0.2500	0.0231	0.0007	0.0000	0.2731	0.2738	0.2738
1.75	0.2222	0.0203	0.0006	0.0000	0.2425	0.2431	0.2431
2.00	0.2000	0.0181	0.0005	0.0000	0.2181	0.2186	0.2186
2.25	0.1818	0.0163	0.0005	0.0000	0.1982	0.1986	0.1986
2.50	0.1667	0.0149	0.0004	0.0000	0.1815	0.1820	0.1820
2.75	0.1538	0.0137	0.0004	0.0000	0.1675	0.1679	0.1679
3.00	0.1429	0.0126	0.0004	0.0000	0.1555	0.1558	0.1559
3.25	0.1333	0.0117	0.0003	0.0000	0.1451	0.1454	0.1454
3.50	0.1250	0.0110	0.0003	0.0000	0.1360	0.1363	0.1363
3.75	0.1176	0.0103	0.0003	0.0000	0.1279	0.1282	0.1282
4.00	0.1111	0.0097	0.0003	0.0000	0.1208	0.1211	0.1211
4.25	0.1053	0.0092	0.0003	0.0000	0.1144	0.1147	0.1147
4.50	0.1000	0.0087	0.0002	0.0000	0.1087	0.1089	0.1089
4.75	0.0952	0.0083	0.0002	0.0000	0.1035	0.1037	0.1037

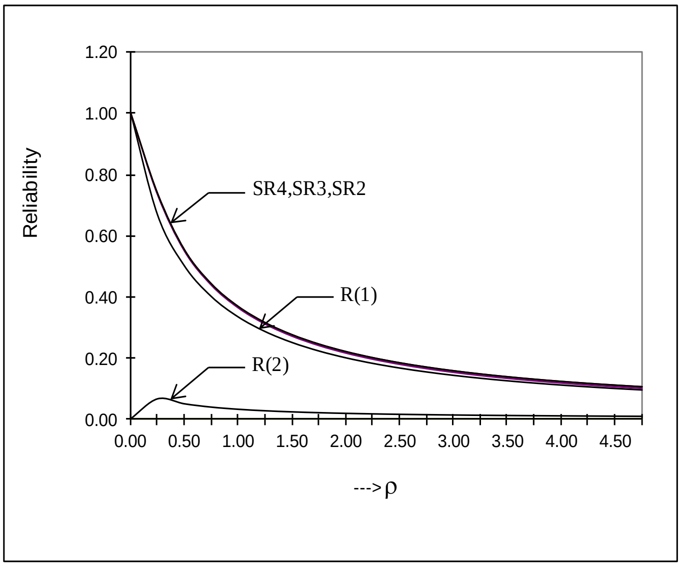

Fig 4: When $\ell_i = (i+1)!\ell$

TABLE V: When $\ell_i = (i-1)!\ell$

ρ	R1	R2	R3	R4	SR2	SR3	SR4
0.00	1.0000	0.0000	0.0000	0.0000	1.0000	1.0000	1.0000
0.25	0.8000	0.1333	0.0238	0.0024	0.9333	0.9571	0.9595
0.50	0.6667	0.1667	0.0333	0.0025	0.8333	0.8667	0.8692
0.75	0.5714	0.1714	0.0346	0.0022	0.7429	0.7775	0.7797
1.00	0.5000	0.1667	0.0333	0.0019	0.6667	0.7000	0.7019
1.25	0.4444	0.1587	0.0313	0.0017	0.6032	0.6345	0.6362
1.50	0.4000	0.1500	0.0292	0.0015	0.5500	0.5792	0.5807
1.75	0.3636	0.1414	0.0272	0.0014	0.5051	0.5323	0.5336
2.00	0.3333	0.1333	0.0254	0.0012	0.4667	0.4921	0.4933
2.25	0.3077	0.1259	0.0238	0.0011	0.4336	0.4573	0.4584
2.50	0.2857	0.1190	0.0223	0.0010	0.4048	0.4270	0.4281
2.75	0.2667	0.1128	0.0210	0.0010	0.3795	0.4005	0.4014
3.00	0.2500	0.1071	0.0198	0.0009	0.3571	0.3769	0.3778
3.25	0.2353	0.1020	0.0187	0.0008	0.3373	0.3560	0.3568
3.50	0.2222	0.0972	0.0178	0.0008	0.3194	0.3372	0.3380
3.75	0.2105	0.0929	0.0169	0.0007	0.3034	0.3203	0.3210
4.00	0.2000	0.0889	0.0161	0.0007	0.2889	0.3050	0.3057
4.25	0.1905	0.0852	0.0154	0.0007	0.2757	0.2911	0.2917
4.50	0.1818	0.0818	0.0147	0.0006	0.2636	0.2783	0.2790
4.75	0.1739	0.0787	0.0141	0.0006	0.2526	0.2667	0.2673

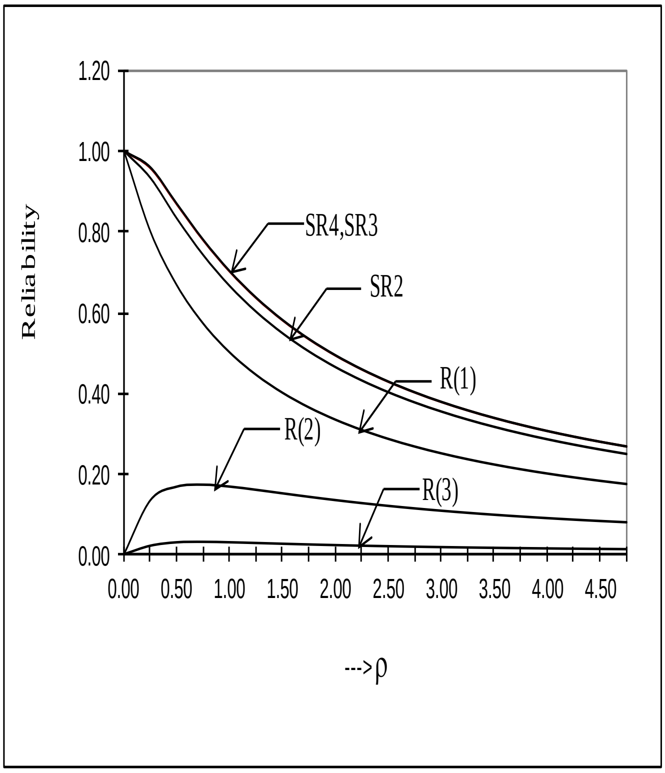

Fig 5: When $\ell_i = (i-1)!\ell$

TABLE VI: When $\ell_i = \ell / i!$

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ρ	R1	R2	R3	R4	SR2	SR3	SR4
0.00	1.0000	0.0000	0.0000	0.0000	1.0000	1.0000	1.0000
0.50	0.6667	0.2286	0.0870	0.0167	0.8952	0.9822	0.9989
2.00	0.3333	0.2500	0.2522	0.1378	0.5833	0.8355	0.9734
2.50	0.2857	0.2339	0.2691	0.1718	0.5196	0.7887	0.9605
3.00	0.2500	0.2182	0.2778	0.2009	0.4682	0.7460	0.9468
3.50	0.2222	0.2036	0.2812	0.2256	0.4259	0.7071	0.9326
4.00	0.2000	0.1905	0.2812	0.2465	0.3905	0.6717	0.9182
4.50	0.1818	0.1787	0.2791	0.2643	0.3605	0.6396	0.9038
5.00	0.1667	0.1681	0.2755	0.2793	0.3347	0.6102	0.8895
5.50	0.1538	0.1586	0.2710	0.2920	0.3124	0.5834	0.8754
6.00	0.1429	0.1500	0.2659	0.3027	0.2929	0.5588	0.8615
6.50	0.1333	0.1423	0.2605	0.3117	0.2756	0.5361	0.8478
7.00	0.1250	0.1353	0.2549	0.3193	0.2603	0.5152	0.8345
7.50	0.1176	0.1289	0.2493	0.3257	0.2465	0.4958	0.8215
8.00	0.1111	0.1231	0.2437	0.3309	0.2342	0.4779	0.8088
8.50	0.1053	0.1177	0.2381	0.3353	0.2230	0.4611	0.7964
9.00	0.1000	0.1129	0.2327	0.3388	0.2129	0.4455	0.7843
9.50	0.0952	0.1083	0.2274	0.3417	0.2036	0.4310	0.7726
10.00	0.0909	0.1042	0.2222	0.3439	0.1951	0.4173	0.7612
10.50	0.0870	0.1003	0.2172	0.3456	0.1873	0.4045	0.7501

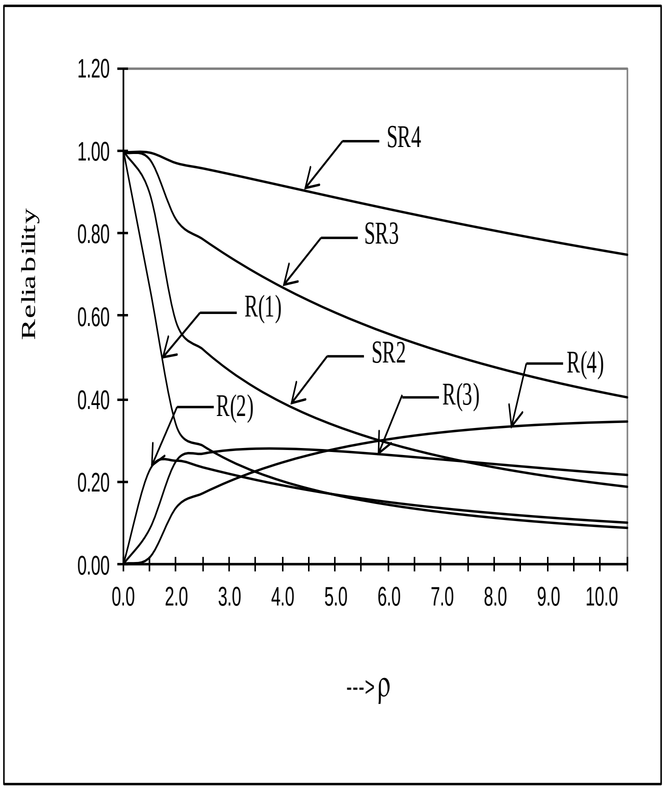

Fig 6: When $\ell_i = \ell / i!$

TABLE VII: When $\ell_i = \ell / (i+1)!$

ρ	R1	R2	R3	R4	SR2	SR3	SR4
0.00	1.0000	0.0000	0.0000	0.0000	1.0000	1.0000	1.0000
1.00	0.6667	0.2571	0.0691	0.0069	0.9238	0.9929	0.9998
2.00	0.5000	0.3214	0.1510	0.0263	0.8214	0.9724	0.9988
3.00	0.4000	0.3333	0.2126	0.0508	0.7333	0.9459	0.9967
4.00	0.3333	0.3273	0.2568	0.0764	0.6606	0.9174	0.9937
5.00	0.2857	0.3147	0.2883	0.1014	0.6004	0.8887	0.9901
6.00	0.2500	0.3000	0.3107	0.1251	0.5500	0.8607	0.9859
7.00	0.2222	0.2851	0.3266	0.1473	0.5073	0.8338	0.9812
8.00	0.2000	0.2707	0.3375	0.1680	0.4707	0.8082	0.9761
9.00	0.1818	0.2571	0.3448	0.1870	0.4390	0.7838	0.9708
10.00	0.1667	0.2446	0.3494	0.2046	0.4112	0.7607	0.9653
11.00	0.1538	0.2329	0.3519	0.2208	0.3868	0.7387	0.9596
12.00	0.1429	0.2222	0.3529	0.2357	0.3651	0.7180	0.9537
13.00	0.1333	0.2123	0.3526	0.2495	0.3457	0.6983	0.9478
14.00	0.1250	0.2032	0.3514	0.2622	0.3282	0.6796	0.9417
15.00	0.1176	0.1948	0.3494	0.2738	0.3125	0.6618	0.9357
16.00	0.1111	0.1870	0.3469	0.2846	0.2981	0.6450	0.9296
17.00	0.1053	0.1798	0.3439	0.2945	0.2851	0.6290	0.9235
18.00	0.1000	0.1731	0.3406	0.3037	0.2731	0.6137	0.9174
19.00	0.0952	0.1668	0.3371	0.3121	0.2621	0.5991	0.9113

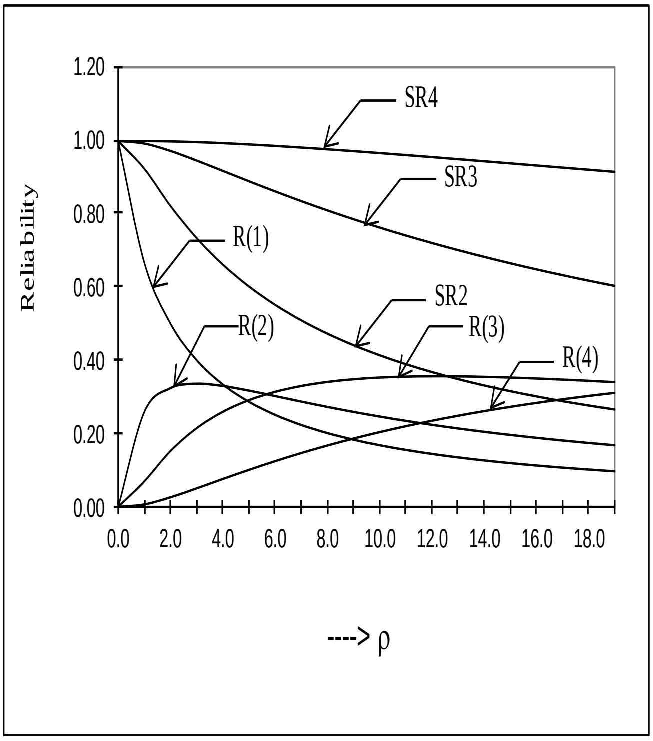

Fig 7: When $\ell_i = \ell / (i+1)!$

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TABLE VIII: When $\ell_i = \ell / (i-1)!$

ρ	R1	R2	R3	R4	SR2	SR3	SR4
0.00	1.0000	0.0000	0.0000	-0.9647	1.0000	1.0000	0.0353
0.25	0.8000	0.1333	0.0497	-0.9098	0.9333	0.9831	0.0732
0.50	0.6667	0.1667	0.1016	-0.8355	0.8333	0.9349	0.0994
0.75	0.5714	0.1714	0.1339	-0.7615	0.7429	0.8768	0.1152
1.00	0.5000	0.1667	0.1524	-0.6947	0.6667	0.8190	0.1243
1.25	0.4444	0.1587	0.1622	-0.6362	0.6032	0.7653	0.1292
1.50	0.4000	0.1500	0.1666	-0.5853	0.5500	0.7166	0.1313
1.75	0.3636	0.1414	0.1677	-0.5409	0.5051	0.6727	0.1318
2.00	0.3333	0.1333	0.1667	-0.5021	0.4667	0.6333	0.1312
2.25	0.3077	0.1259	0.1644	-0.4680	0.4336	0.5980	0.1299
2.50	0.2857	0.1190	0.1613	-0.4378	0.4048	0.5661	0.1282
2.75	0.2667	0.1128	0.1578	-0.4110	0.3795	0.5373	0.1263
3.00	0.2500	0.1071	0.1540	-0.3869	0.3571	0.5112	0.1242
3.25	0.2353	0.1020	0.1501	-0.3653	0.3373	0.4874	0.1221
3.50	0.2222	0.0972	0.1462	-0.3457	0.3194	0.4656	0.1199
3.75	0.2105	0.0929	0.1423	-0.3280	0.3034	0.4457	0.1178
4.00	0.2000	0.0889	0.1385	-0.3118	0.2889	0.4274	0.1156
4.25	0.1905	0.0852	0.1348	-0.2969	0.2757	0.4105	0.1136
4.50	0.1818	0.0818	0.1313	-0.2833	0.2636	0.3949	0.1116
4.75	0.1739	0.0787	0.1278	-0.2707	0.2526	0.3804	0.1097

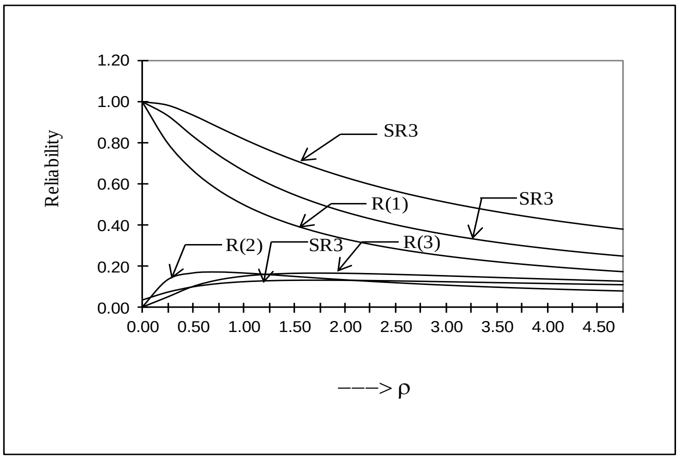

Fig 8: When $\ell_i = \ell / (i-1)!$

III. CONCLUSION

From case 1 to 7 the results are shown in Table 1 to 7 and Fig.1 to 7, for different values of ℓ , we observed that there is very good improvement in Reliability. Where as in case 8 , shown in Table 8 and Fig. 8, there is a very little Reliability improvement. Hence we infer that, systems with lesser parameter values are more reliable when the stress and strength distributions are weibull.

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Currently working under Ministry of Manpower, Sultanate of Oman, and Faculty in Mathematics at the Department of Information Technology, IBRA COLLEGE OF TECHNOLOGY, and IBRA, OMAN from November 2007. He Worked under U.N.D.P as Assistant Professor in Mathematics at Arbaminch University, ETHIOPIA from September 2004 to October 2007.Also, he worked as Assistant Professor in Mathematics at the University of Arts & Science College, Kakatiya University, Warangal,(A.P),INDIA from June 1991 to August 2004, taught Mathematics and statistics in the Post-Graduate , Under- Graduate and Engineering classes. Received his PhD in Mathematics entitled "CASE STUDIES OF STRESS-STRENGTH CASCADE RELIABILITY MODELS" from Kakatiya University in 1997. Research papers were published in National and International Journals. And also some papers are in consideration for publication in different International Journals. He was the Member of Indian Education Forum, Embassy of India, and ETHIOPIA. He was the Life member of Andhra Pradesh Society for Mathematical Sciences, Hyderabad, INDIA.