Society for Reliability and Safety Website: http://www.sresa.org.in For private circulation only

# SRESA Newsletter

Oct-Dec-2020 Issue

A quarterly publication of Society for Reliability and Safety [Reg. No. 3141/2010/G.B.B.S.D.], Mumbai

New SRESA's 10th Anniversary Celebration: Webinar on 26th December 2020; 1030 – 1330 hrs



**SRESA Mission**

*To provide a platform for accelerate growth of the reliability and safety program for complex safety and mission critical systems towards effectively contributing to the 'make in India' and Atmanirbhar Bharat initiative*

*From the President's Desk ....*

It is indeed my pleasure to bring to the kind notice of the readers that SRESA's 10th Anniversary will be celebrated on 26th December 2020.

It is very satisfying and proud moment for the SRESA members that their initiatives and sustained efforts are bearing the results now. Be it organizing series of international and national events i.e. ICRESH and NCRS, respectively; launching of the SRESA Int. Journal and achieving many more targets successfully during this period of ten years.

In 2012, the SRESA Journal of life Cycle Reliability and Safety Engineering – a quarterly journal was launched. The high quality of publications made this journal as one of the well-recognized international journals in the area of risk and reliability. Publication of this journal by Springer, since 2016 onwards is a testimony to this success story. This journal has now become truly international in the sense that we now receive manuscripts from many countries apart from India. Further steps for Scopus and UGC registration is in advanced stages.

I Invite you all for the SRESA's 10th Anniversary. Looking forward to seeing you in the webinar

- Prabhakar V. Varde

In this issue ....



## Incorporation of Plant Operating State in Surveillance Test Interval Evaluation

**Arihant Jain , Scientific Officer , RRSD, RG, BARC**

Safety systems in nuclear plants are required to be in standby state. Periodic inspection and testing of such systems is important to maintain operational preparedness of the safety critical systems. Surveillance test interval (STI) is very important for the standby systems. With an objective to minimize system unavailability, optimization of STI plays a very important role in Risk-informed testing / maintenance.

Test intervals are mostly decided conservatively qualitative criteria that include, based on operational experience, expert advice and manufacturer's recommendations. Probabilistic techniques allow to take risk-informed decision on surveillance test interval (STI) that aims at minimizing mean system unavailability. Risk-based Surveillance Test Interval optimization can be carried out using results of Probabilistic Safety Assessment (PSA).

which core damage frequency (CDF) is considered as optimizing criteria.

During surveillance testing the system remains unavailable to cater any mand occurrence. This factor pushes the optimum surveillance interval higher frequent testing causes higher unavailability due to increased contribution of sting time. The available models do not take into account the existing plant nditions during testing for determination of optimum STI. As is observed in some nts, the surveillance testing of safety critical systems is carried out during plant utdown. During shutdown, the pressure and temperature is significantly lower an that during full power operation. This reduces the possibility of any demand currence on the safety systems. Available models either assume similar demand currence frequency during shutdown as that during normal operation or nsider no demand occurrence during shutdown. It was felt that neither of the o scenarios take into account the actual plant conditions and hence give results at are on extreme ends. To incorporate the effect of reduction in demand currence frequency during surveillance testing, a parameter p, that is the ratio demand occurrence frequency during testing to the demand occurrence quency during normal operation, is used.

As shown in Figure 1, the total time (surveillance test interval, T) for a fety system is divided into the time spent in standby state ($t_1$) and time spent ring testing ($t_2$). I & $II$ are the two operating states i.e. standby and testing spectively.

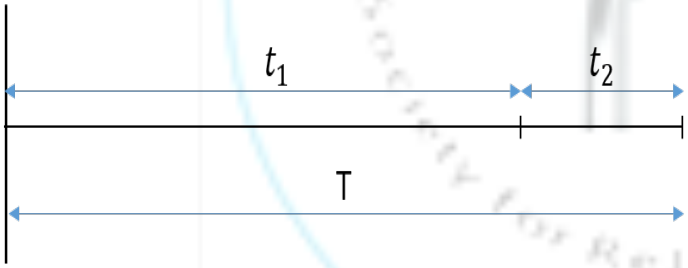



Figure 1: Time spent by standby safety system in various states

$p$ is given by:

$$p = \frac{\nu_{II}}{\nu_I} \qquad (1)$$

Where, $\nu_I$ and $\nu_{II}$ are the demand occurrence frequencies in operating nditions I and II respectively.

Value of p ranges from zero to one corresponding to the relative quency of demand occurrence during testing to that during standby operation. e probability of demand occurrence during testing is hence modified as:

$$P(II) = p\frac{t_2}{T} \qquad (2)$$

Mean unavailability is then given as:

$$P(U) = P(U|I) + p\frac{t_2}{T}\{1 - P(U|I)\} \qquad (3)$$

The effect of p on mean unavailability of a system with constant failure rate is shown in Figure 2.

## Case Study

A case study is performed on Emergency Core Cooling System of Reference Reactor. The objective is to study the trend of optimum STI with p.

ECCS is tested quarterly to ensure operational readiness in case of any emergency. During surveillance testing, the system remains unavailable to cater any demand. Testing is carried out during reactor shutdown with the temperature and pressure in the primary heat transport system significantly lower than that during reactor operation. Hence the possibility of demand occurrence (LOCA) is also lower during ECCS testing. This effect is considered by assigning appropriate value to parameter p. Increasing value of parameter p indicates that the LOCA frequency during reactor shutdown is increasing relative to the possibility of LOCA during reactor full power operation with $p = 1$ indicating that there is reactor shutdown does not affect LOCA frequency.

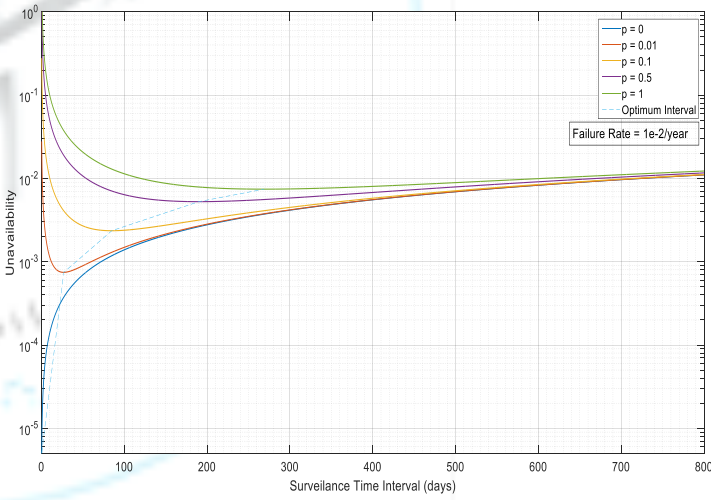



Figure 2: Effect of 'p' on unavailability of a system with STI

Optimum STI (minimum unavailability) of ECCS system for various values of p has been estimated to be 0, 34, 110, 246, 348 days for p values of 0,.00, 0.01, 0.1,, 0.5 and 1.0 respectively. The increase in optimum STI is attributed to the increased contribution of unavailability during testing with increase in p.

Shri Arihant Jain has worked as Scientific Officer at Bhabha Atomic Research Center, Trombay, Mumbai from July 2016 to August 2020. He did his M.Tech (Mechanical Engineering) in the year 2016 from Indian Institute of Technology Kanpur with specialization in Solid Mechanics and Design. He has done B.E. in Mechanical Engineering from Shri G.S. Institute of Technology, Indore. Presently, Shri Jain is pursuing his management graduation at IIM, Bangalore.

# Why Perform Remaining-Life Analysis for Infrastructures and not a Structural Audit

**Sharvil Alex Faroz, Founder CEO, Infrastructure Risk Management (IRM), Mumbai**

**Fear of the Unknown**

I am going to assume few things here. You are an infrastructure asset owner or an executive engineer or a minister. You were thinking of the latest bridge collapse and the number of lives lost in it, and the future action plan to avoid such a tragedy. Note, I am using bridges in this article, but the argument is valid for all critical infrastructures; Power Plants, Ports & Harbours, Dams, etc.

Imagine the shock and pain you have after your bridge has collapsed and someone or our own loved one is suffering grievously in such an incident. The quick and sudden requirement of funds to treat your family or for rehabilitation of the bridge is unaccounted for and that's why you do not have sufficient money now. Since 2016 there is at least one bridge collapse every year in our country. Based on the statistics of national highways (NH) reported in 2017, it is found that, 6551 bridges are structurally deficient and out of these bridges, 86% are below the age of 50 years [3]. This statistic comprises of 5591 minor bridges, 664 major bridges and 296 extra-long bridges [4]. To give you a point of view, the NH bridges are merely 3% of all the bridges in the country, just imagine the vastness of the issue. You don't know beforehand which one of these will collapse first or will 'you' become its victim. Is there any salvation? Read on...

*Cause of Failure*

Leaving aside the deficiency in design and details, deterioration is the primary cause of such failures. Major deteriorations of reinforced concrete (RC) include reinforcement corrosion due to chloride ingress/carbonation of concrete, loss of concrete strength, loss of prestress and fatigue, etc. You would ask me, "If these are the factors, why bridges still continue to collapse? Can't we control them? "Off-course yes ! But there is a fundamental block among the engineering fraternity in general today...

*The Real Cause of Failure*

One of the most profound statement I have come across is this; Old RC structures are undergoing deterioration faster, because the mechanism of degradation was not understood well at the time of construction [5] and was not taken into account in the planning.

In conventional engineering we were not taught to consider deterioration of infrastructures. Remember your 4th year of engineering, we studied "design of concrete structures". We were taught to design for a given distributed load, or a bending moment, but not taught to design a structure considering, it will corrode in 10 years or how to consider corrosion. Thus, in essence, the conventional engineers consider the performance of structures as shown in Fig. 1 which is non-degrading over time.

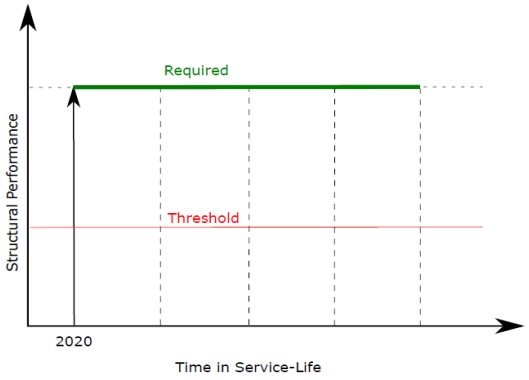



Figure 1: Structural behavior taught in our engineering

The uncertainty associated with the deterioration and life cycle loads poses a major challenge to designers. It requires advanced degradation models, complex monitoring techniques and a system to to predict incipient failures in advance.

To give you an analogy, suppose you did not account a particular load in structural design. What will happen when that load comes on the structure, it will fail. Since the engineers did not account deterioration in design and they are not competent to handle it, this is the real reason for infrastructure failures.

## Remaining-Life Analysis

In a common Structural Audit, engineers perform tests on the bridge and evaluate only its instantaneous performance at time $t_1$ (Fig. 2). They consider the same capacity of the previous audit until the consecutive audit is done, at $t_2$, when they re-test. The reason for this is the explanation behind Fig.1.

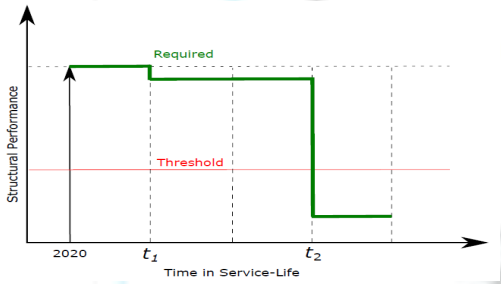



Figure 2: Structural Audit

It is possible that bridge failure can occur before your next audit ($t_2$), because you gain no knowledge about its future behavior from a conventional audit. Mostly the decision to do an audit is initiated based on visual inspection. The New Zealand Transport Agency confirmed that 'visuals can be misleading', because the Sorrell Causeway Bridge suddenly collapsed with no obvious visual distress [6]. This indicates that many, bridges may already be in a severely weakened state while still passing a visual inspection test without detection of damage.

But now, it is possible to tell you just exactly when your bridge is about to fail or when it is due for a major rehabilitation [1, 2]. In a Remaining-Life Analysis (RLA) you are empowered through a deterioration analysis to "see" the behavior of your bridge in the years to come and inform you proactively when you have a dangerous situation in future, see Fig.3.

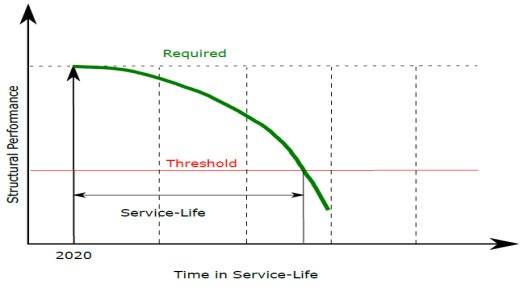



Figure 3: Remaining-Life Analysis (RLA)

The most important benefits you get from RLA is seen in Fig. 4. As you already know the behavior of the bridge in the coming years you are forewarned of its end of life. Usually when there is a sudden collapse you are into panic and might make a hasty decision which could be unwise in the long-term. But because you "see" through RLA you are prepared to combat future rehabilitation by accumulating funds, rather than digging a well when there is fire. Plus, you can do a proactive life cycle planning (which is impossible in an audit), which can minimize your cost and the bridge can have a target life extension with confidence. I always say, "Infrastructures don't demand RLA, they deserve it".

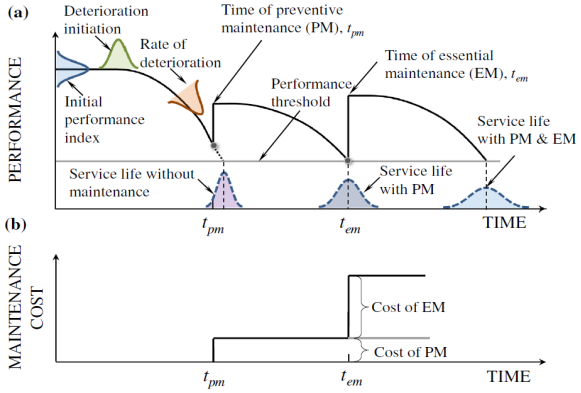



Figure 4: Lifecycle gain from RLA

## Conclusion

Remaining-Life Analysis is about care and honesty. It benefits those, who really want to see their Nation as a superpower by avoiding its enormous losses from infrastructure failures. There are three qualifiers, to check if RLA is for you: 1) You are wise and knowledgeable, 2) You are proactive, and 3) You don't compromise for the Nation. If you fit in all three criteria, the world is open for you.

## References

[1] S. A. Faroz. *Assessment and Prognosis of Corroding Reinforced Concrete Structures through Bayesian Inference*. PhD thesis, Indian Institute of Technology Bombay, Mumbai, India,2017.

[2] S. A. Faroz and S. Ghosh. Bayesian integration of NDT with corrosion model for service-life predictions. In *Proceedings of IABMAS 2018*, Melbourne, Australia,2018.

[3] S. Joshi, N. Naga, and U. Rajesh. Experience of Management of Bridges Prior to and Post Evaluation of BMS on NH network of India. In *Proceedings of IABMAS 2018*, Melbourne, Australia,2018.

[4] S. Joshi and S. S. Raju. Indian Bridge Management System - Overview and Way forward. In *Proceedings of IABMAS 2018*, Melbourne, Australia, 2018.

[5] P.S. Marshand D.M. Frangopol. Reinforced concrete bridge deck reliability model incorporating temporal and spatial variations of probabilistic corrosion rate sensor data. *Reliability Engg. and System Safety*, 93(3),2008.

[6] R. A. Rogers, M. Al-Ani, and J. M. Ingham. Assessing pre-tensioned reinforcement corrosion within the New Zealand concrete bridge stock. Technical report, NZ Transport Agency research report 502, Wellington, New Zealand,2013.

Dr Sharvil Alex Faroz holds a PhD in structural engineering from IIT Bombay. He is founder of, "Infrastructure Risk Management", a company, to help bridge owners avoid unexpected failures by analysing their Remaining-Life and proactively implementing Service-Life Extension strategies. After the Gokhale bridge collapse in 2018, Dr. Sharvil has worked first-hand with Central Railway for the Vulnerability Assessment of 157 bridges.

He has published 17 journal papers and now writing a book on 120 years Maintenance-Free Life for marine bridges. He has been a speaker at 2 International platforms, twice delivered live telecasts and deliberated on 19 National forums to share his technology with the authorities.

Dr. Sharvil is evolving with infrastructure projects of Remaining Life Analysis, Target Life Rehabilitation and providing Maintenance-Free Life for new bridges. He is active on linkedin and connects with motivated people and clients. You can visit his company at www.IRM365.in

## Dr. Rajkumar B. Patil's Completed his Post-Doctoral Research at, CALCE, University of Maryland, USA

I, SRESA member since 2014 and coordinator of SRESA Sangli Chapter, am pleased to inform you that I successfully completed my post-doctoral research at Center for Advanced Life Cycle Engineering (CALCE), University of Maryland, College Park, USA from September 3, 2019 to September 4, 2020. I got an opportunity to work on different collaborative research projects supervised by Prof. Michael Pecht. I also contributed to a graduate course "Design for Reliability". This research and academic experience helped to improve my research and academic skills and would definitely help to my students and faculty colleagues at Annasaheb Dange College of Engineering and Technology, Ashta, Sangli. The research and academic outcomes of the post-doctoral research studies are as follows:

**Research Projects:** I worked on following on-going projects with the CALCE team :

- Evaluation of FIDES: Reliability prediction methodologies for electronics based on IEEE 1413. The project was funded by National Aeronautics and Space Administration (NASA).
- Assessment of reliability allocation methodologies for electronics.
- The existence and applicability of bathtub curve to electronic components, products, and systems.
- Fault tree analysis of Li-ion battery.
- Writing books on "Common Cause Failures" and "Reliability Distributions".

Based on my research and development work at CALCE three papers have been submitted for publication with me being one of the co-authors.

**Academic Activities:** I worked as a teaching staff for a graduate course "Design for Reliability (ENME 695)" with following key contributions:

- Curriculum upgradation.
- Updation of course PPTs, videos, homework questions, and reading material.
- Took classes on Software for reliability data analysis: Weibull++, Software for test data analysis: ALTA; Reliability block diagram; Failure modes and effects analysis (FMEA); Fault tree analysis (FTA); Markov chains; and System reliability, maintainability and availability modeling and analysis software: BlockSim.
- Set mid-term and final exam question papers.
- Assessment and grading using online system called as CANVAS.

# Sad Demise of Prof. Sukhjeet Singh

It's with grief and sorrow we bring we bring to your kind notice the untimely and sad demise of Prof. Sukhjeet Singh on October 11, 2020. We are deeply saddened and are finding it difficult to comprehend the sudden loss of Prof. Sukhjeet Singh. Prof. Singh was a very active and dynamic member of the SRESA executive committee. In a, relatively short period of over an year, he contributed to SRESA activities significantly.

Sukhjeet Singh was an Assistant Professor in the Department of Mechanical Engineering at Guru Nanak Dev University Regional Campus Sathiala (Distt. Amritsar), Punjab, India. He completed his PhD (Mechanical Engineering) from Indian Institute of Technology (IIT), Ropar, India. Earlier, and Bachelor's (Mechanical Engineering) and Masters Degree (Mechanical Engineering with specialization in Machine Design) from Punjab Technical University, Kapurthala, Punjab, India. His research interests included mathematical as well as experimental aspects of vibration analysis, rotor dynamics, signal processing and machine learning techniques.

On behalf of SRESA we extend our condolences to Singh family and pray to the almighty to give courage and strength to bear this loss. SRESA will always remember Prof. Sukhjeet Sigh as a man of action with respect.

SRESA Executive Committee

# SRESA welcomes New members

**Amrinder Singh Minhas** is a Research scholar in the department of Mechanical Engineering at Guru Nanak Dev University Regional campus Sathiala (Distt. Amritsar), Punjab, India. He received his Master's degree from Punjab Technical University, Kapurthala, Punjab, India., in 2013 with specialization in Machine Design.

His research interests include signal processing applications for diagnosis and prognosis of faults in rotor dynamics through mathematical modeling and experimentation.

**Snehsheel Sharma** is a Research scholar in the department of Mechanical Engineering at Dr. B.R. Ambedkar National Institute of Technology, Jalandhar, Punjab, India. He has received his Master's degree from Punjab Technical University, Kapurthala, Punjab, India. in 2007 with specialization in Production Engineering.

His research interests include condition monitoring of rotary machines especially diagnosing the different faults in various kind of gearboxes through signal processing techniques.

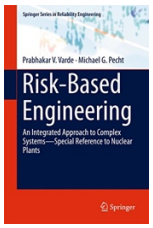
**Vinay Vakharia** is currently working as an Assistant Professor in Department of Mechanical Engineering, School of Technology, Pandit Deendayal Petroleum University, Gandhinagar, Gujarat, India. He completed his Ph.D. from PDPM IIITDM Jabalpur in the area of Bearing Fault Diagnosis Using Signal Processing Techniques and Machine Learning. His areas of research are Tool Condition Monitoring, Application of Image Processing Techniques for Texture Characterization of Machined Components, Fault Severity Analysis etc.

**P.K. Kankar** is working as an Assistant Professor in Mechanical Engineering Discipline, PDPM-Indian Institute of Information Technology, Design and Manufacturing Jabalpur. He obtained his Ph.D. from the Mechanical and Industrial Engineering Department at Indian Institute of Technology Roorkee, India. His research interests include vibration, design, condition monitoring of mechanical components, nonlinear dynamics, soft computing etc. He published more than 85 papers in refereed journals and conferences. He is a member of professional bodies like American Society of Mechanical Engineers, Annual, Society for Reliability and Safety (SRESA), Tribology Society of India and International Institute of Acoustics & Vibration (IIAV).

Shri V.K. Gautam is AMIE (Mech. Engg.) and MBA (Operations Management). He is working in IF3 division of BARC as an Officer-in-charge, Technical Services Section. He has to ensure high reliability of availability of services through preventive and predictive maintenance for smooth operation of the facility. He has served as a member of Regulatory Inspection Team and member of Design Safety Review Committee for a specific facility. He is also a member of Material Handling Equipment Committee.

# Book Publication

**Prof.. Prabhakar V. Varde, BARC, India co-authored a book with Prof. Michael G. Pecht, University of Maryland, USA, published by Springer, entitled "*Risk-Based Engineering: An Integrated Approach to Complex Systems – Special Reference to Nuclear Plants*".**




The book comprehensively covers the various aspects of risk modeling and analysis in technological contexts. It pursues a systems approach to model risk and reliability concerns in engineering. It covers the key concepts of risk analysis and the mathematical tools used to assess and account for risk in engineering problems. The relevance of incorporating risk-based structures in design and operations is also stressed, with special emphasis on the human factor and behavioral risks. The book uses nuclear plant, an extremely complex that is having high-precision engineering environment, as an example to develop the concepts discussed. The core mechanical, electronic and physical aspects of such a complex system offer an excellent platform for analyzing and creating risk-based models.

The book in a separate section also provides real-time case studies to demonstrate the use of this approach. There are many limitations when it comes to applications of risk-based approaches to engineering problems. The book is structured and written in a way that addresses these key gap areas to help optimize the overall methodology. This book will serve as a textbook for graduate and advanced undergraduate courses on risk and reliability in engineering. It can also be used outside the classroom for professional development courses aimed at practicing engineers or as an introduction to risk-based engineering for professionals, researchers, and students interested in the field.

# Invitation for the 10th SRESA Anniversary Webinar

Activities related to formation of a reliability society were initiated while organizing the first international conference on Reliability Safety and Hazard 2005 (ICRESH-2005), in Mumbai, A formal proposal was presented to the ICRESH-2005 final summary meeting. The reliability and probabilistic safety assessment (PSA) programme which essentially was initiated at BARC during early eighties had grown all over institutions like AERB, NPCIL, HWB, IGCAR, ISRO, etc and around the same time reliability centers came into existence in institutions, like IIT, Kharagpur, IIT Bombay, CFR, in Chennai. All these developments gave the required impetus to have a reliability society. It was also realized that risk and mission critical systems like nuclear, process, space, aviation and transport systems have their primary focus on safety along with reliability. It took around 5 years when the Society for Reliability and Safety (SRESA) was finally registered under Society Act with Charity Commissioner's Office in Mumbai on 26th Day of year 2010.

In last 10 years the SRESA has grown in terms of membership from initial 10 in 2005 to over 180. SRESA also organized four each, series of national and international events, namely NCRS and ICRESH in 10 years, The SRESA Journal of Life Cycle Reliability and Safety is the flag bearer at national and international level. This event which marks 10 years of SRESA services in the area of reliability and safety, also kickstarts celebration of 'SRESA founder day' in the coming years. We are happy to inform you that Dr. Kallol Roy, Chairman and Managing Director, BHAVINI will be the Chief Guest and Prof. Ajit Kumar Verma, Professor, Western Norway University of Applied Science, Norway will deliver the Webinar Inaugural Kay note address for this event.

SRESA Executive Committee invites you all to join the Webinar on 10th December 2020. For further information and updates please visit the SRESA website www.sresa.org.in or write to secretary@sresa.org.in

For Information on International Conferences in the area of Risk and Reliability Follow the link:

https://conferenceindex.org/conferences/reliability

## Invitation for Contribution to the Newsletter

SRESA Newsletter published Articles under the following major categories:

1. Brief technical article up to four pages (Max.) discussing a new idea, design, achievement in operational performance, major result(s)/finding(s) of a study or experiment, and review.
2. Insights and experiences of collaborative research, development and applied research work, visiting position and postdoctoral research, academic achievements,
3. Book review particularly, review of book written by SRESA members.
4. Announcement of upcoming conferences of having relevance to SRESA members.
5. Major events organized and activities by SRESA chapters
6. Information on publications in the form of extended abstracts by SRESA members for wider publicity

For submission of article editor on contact: newsletter@sresa.org.in, editor@sresa.org.in

SRESA invites the engineering professionals to become member of the Society. The SRESA membership forms duly filled and signed along with applicable membership fee, as per the guidance provided at the bottom of the membership form, should be sent to the Hon Secretary SRESA at secretary@sresa.org.in. Once the SRESA executive committee approves the membership, the same will be communicated by email along with the membership Certificate. For details visit SRESA web-site: www.sresa.org.in

# Society for Reliability & Safety (SRESA)

(REG. NO. :F-43051 (Mumbai))
SRESA COORDINATOR, SHRI S.J. RAUT, 64-VIBHA, R. PARAMHANS MARG
OPP. CARDINAL GRACIOUS HIGH SCHOOL; BANDRA(E) MUMBAI - 400051
Web Site: www.sresa.org.in (PHONE ; +91-22-25596206)

**MEMBERSHIP APPLICATION FORM.** **MEMBERSHIP NO*.**



| | | | |
|---|---|---|---|
| 1. | Name of applicant | | Photograph (Affix passport size photograph above and send one additional softcopy with email) |
| 2. | Qualification | | |
| 3. | Affiliation | | |
| 4. | Position held | | |
| 5. | Specialization | | |
| 6. | Official address ☐ \| Residential Address ☐<br>(Please tick the address to be used for official communication) | | |
| 7. | Cell phone number(s) | | |
| 8. | Email | | |
| 9. | Date of birth (DD/MM/YY) | | |
| 10. | Type of membership (Tick applicable category) | Life membership : Rs. 2,200/-<br>Corporate membership : Rs 50,000/-<br>Annual student membership : Rs 500/-<br>(Please tick the applicable category) | ☐<br>☐<br>☐ |
| 11. | Payment mode:<br>i) Cheque ☐ ii) Demand draft ☐ iii) On-line transfer: ☐<br>Cheque /DD/online transfer details :……..Date: …….<br>Amount: ……<br>Name of the Bank:……Account number……ISFC code | | |
| 12 | Applicant's Signature: | | |

- Kindly send the scanned copy of the form duly signed by email to Secretary, SRES along with a soft copy of the passport size photograph at secretary@sresa.org.in
- SRESA account details are as follow : Money to be transferred in favour of 'Society for Reliability and Safety', Bank Name: State Bank of India, Account number : 31110442604, Swift Code SBININBB508, Branch: BARC, Mumbai-400085.
- *will be allotted by SRESA Office.