Issue 17

August 2017

SFA Newsletter

Seasons Greetings!

About SFA

Objectives

Local centers

Welcome you all to join as members of SFA! Please find the membership form inside; kindly fill in and contact Secretary of SFA through email.

Experts and experiences:

- Prof.S.R.Satish Kumar, IIT, Madras
- Dr.Prasanta Kumar Rout, Tripura University

Message from our President

Dear readers,

Warm seasons greetings! I am happy to find the SEVENTEENTH issue of SFA newsletter rolling out coinciding with the famous festival season that gets underway in August in India. While all of us enjoy some of India's most popular and traditional festivals and celebrations, it is my humble appeal to all my colleagues to nurture brotherhood and revelry towards one another. August month celebrates the birth of a famous structural engineer, Eugene Figg who worked diligently to combine function and form in his creation of some of the most aesthetically pleasing bridges ever designed. This makes me remind all of you of the quotation:"refuse to lower your standards to those who refuse to raise their standards".

Best wishes to all the readers!

P.Jayapal
PRESIDENT, SFA

Edited by: Dr.P.Parameswaran, Metallurgy & Materials Group, IGCAR, Kalpakkam

From the Desk of Editors

Seasons Greetings! You are glancing through the seventeenth issue of the Newsletter of Society for Failure Analysis (SFA). Our efforts to build the society have seen success, progressing well during the past few years with the conduct of several activities by our local centres at various places. The successful conduct of general body meeting at various chapters is due in last few month and many have taken steps.

We solicited articles for the current issue from failure analysis experts of our country who had worked on many case histories.

We thank the two authors for their contributions which are quite interesting studies – one on "stress corrosion cracking in Al alloys" by Dr.Prasanta Kumar Rout, Tripura University and another on "Structural failures" from Prof.S.R.Satish Kumar, IIT Madras - for the current issue.

We take this opportunity to appeal to the Indian industry to use SFA as a forum to share their experiences on trouble shooting. A great way to add content to this newsletter is to include a calendar of upcoming events. The details of important forthcoming international and national events are included; so also the books recently published on the topics of the subject.

We value your comments, which really boost our enthusiasm to perform better. Therefore, as always, your views and comments, mailed to param@igcar.gov.in are welcome. We wish you all success free of failures and a joyful life!

You may visit our web site for your comments/suggestions or any queries: www.sfaindia.org

Kalpakkam

31-08-2017 (P .Parameswaran)

Editor

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*We encourage you to join the society, Kindly fill up the application form (enclosed at the end of the newsletter) and contact secretary: pjayapal59@yahoo.co.in; alternatively, post your application with draft to Sri.B Jana, Treasurer, **RCMA,** CEMILAC, Kanchanbagh, Hyderabad, 500 058*

About the society

Aims and Objectives of Society for Failure Analysis

The aims and objectives of the Society shall be:

To serve as National Society to promote, encourage and develop the growth of "Art and Science of Failure Analysis" and to stimulate interest in compilation of a database, for effective identification of root causes of failures and their prevention thereof.

To serve as a common forum for individuals, institutions, organizations and Industries interested in the above.

To disseminate information concerning developments both in India and abroad in the related fields.

To organize lectures, discussions, conferences, seminars, colloquia, courses related to failure analysis and to provide a valuable feed back on failure analysis covering design, materials, maintenance and manufacturing deficiencies / limitations.

To train personnel in investigation on failures of engineering components and their mitigation.

To identify and recommend areas for research and development work in the Country relating to failure analysis.

To establish liaison with Government, individuals, institutions and commercial bodies on failure analysis, methodologies and to advise on request.

To cooperate with other professional bodies having similar objectives.

To affiliate itself to appropriate international organization(s), for the promotion of common objectives and to represent them in India.

To organize regional chapters in different parts of the country as and when the need arises.

To do all such other acts as the Society may think necessary, incidental or conducive to the attainment of the aims and objectives of the Society.

Know your local centers

STRESS CORROSION CRACKING
(*A MAJOR ISSUE IN ALUMINIUM ALLOYS*)

Dr. Prasanta Kumar Rout
Assistant Professor
Dept. of Material Science and Engineering
Tripura University

1. Introduction

Stress corrosion cracking (SCC) is a cracking phenomenon that occurs in susceptible metals and alloys, and is caused by the conjoint action a of tensile stress (stress level must be above some threshold value) and the presence of a specific corrosive environment. The schematic representation of SCC is shown in the figure 1(a,b).

Stress corrosion crack may be transgranular, intergranular or mixed mode depending on alloy/environment system and loading mode as well. This cracking phenomenon is of grave concern which has initiated several researchers to dwell at length on the phenomenon as SCC leads to catastrophic failure under service conditions without any prior warning**.** Among the various alloy systems subjected to SCC which is listed in Table 1[1], aluminium alloys are important. As per the data published in literatures and case histories data, the frequency of failure modes in engineering components and aircraft components is listed in the Table 2 [2]. 7xxx series Al-Zn-Mg-(Cu) alloys have the maximum strength amongst the age hardenable aluminium alloys and are used in the aircraft, armored fighting vehicles and automotive industries for structural components in their maximum strength (T6 temper) condition. In fact, these alloys have experienced increasing levels of use in recent years and have replaced materials such as wood, copper, and steel in many engineering applications. However, these alloys in peak aged (T6 temper) condition undergo stress corrosion cracking (SCC) in aqueous solution containing particularly active chloride ions [3,4]. This can strongly reduce the service life of aerospace components having a negative effect on safety and cost.

a)

b)

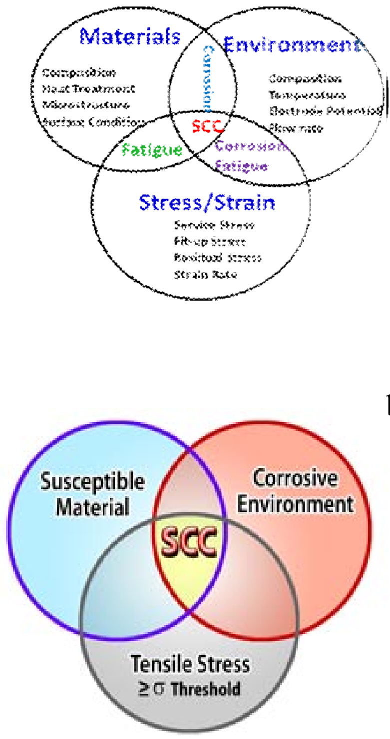

Figure 1. Schematic representation of stress corrosion cracking (SCC) phenomenon.

Although SCC is a well documented phenomenon, there is a still considerable disagreement in the literatures regarding the operating mechanism. The mechanism of

Table 1. Stress corrosion cracking susceptibility of some metal/alloys in specific environments

Metal/Alloy	SCC susceptibility environment
Aluminium alloy	Sodium chloride (NaCl solution), Seawater, Mercury
Copper alloy	NH_3 vapor, NH_3 solution, Mercury
Magnesium alloy	Rural and coastal atmosphere, Distilled water, NaCl solution, Potassium dichromate solution
Inconel	Caustic soda solution
Gold alloy	Ferric chloride solution, Acetic acid/salt solution
Lead	Lead acetate solution
Nickel	Fused caustic soda
Carbon steels	Sodium hydroxide solution, Sodium silicate solution, calcium Nitrate, Seawater, Mixed acid, Ammonium nitrate, Hydrogen sulfide
Stainless steels	Barium chloride and Magnesium chloride solution, NaCl-H_2O_2 solution, Seawater, NaOH-H_2S solution
Titanium alloy	Red fuming nitric acid

Table 2. Frequency of failure mode

Failure type	Percentage of failure	
	Engineering components	*Aircraft components*
Corrosion	29	16
Fatigue	25	55
Brittle fracture	16	-
Overload	11	14
High temperature corrosion	7	2
SCC/Corrosion fatigue/HE	6	7
Creep	3	-
Wear/Abrasion/Erosion	3	6

failure is still far from established and convincing evidence to make a choice among different proposed theories or model is lacking. In spite of active research have been carried out for several decades, this field of research is still very vibrant and active because the role of metallurgical factors on SCC is very complex. SCC mechanism is not fully understood till date. In this context, it is to highlight that (i) the size and distribution of matrix strengthening and grain boundary precipitates, (ii) the presence of coarse intermetallic dispersoids (intra- and intergranular) and particles, (iii) width of precipitate free zone (PFZ), (iv) grain sizes and (v) their orientations etc. and the environmental factors e.g. (a) pH of the medium, (b) nature of electrolyte and (c) applied potentials which have pronounced influence/effect on the stress corrosion cracking tendency [5-7]. Therefore, it is emphasized that the SCC process of Al-Zn-Mg-Cu alloys is a very complex interplay amongst the microstructural features, environmental conditions, and state of stress situations as well. The present note brings out the research on assessment of SCC behaviour of 7xxs series Al-Zn-Mg-(Cu) alloys briefly as follows.

2. Experimentation

As it is well known and established that the Al-Zn-Mg-Cu alloys provide highest strength in their peak aged (T6) condition, but unfortunately the alloy is susceptible to stress corrosion cracking (SCC). On the other hand, over aged tempers (i.e. T7 and T7X) have higher resistance to SCC but with 10-15% lower strength compared to that of T6 temper. Efforts have been directed towards developing new heat treatment / ageing schedule to optimize both strength and SCC resistance of the Al-Zn-Mg-Cu alloys by altering microstructural features.

In this context, Rout *et al* [7] made attempt to develop and re-establish some novel ageing technique (listed in Table 3) such as high temperature pre-precipitation (HTPP) ageing and interrupted ageing (T6I6) to increase the SCC resistance of a high strength 7150 alloy. The chemical composition of the 7150 alloy is given in Table 4. The SCC studies were carried out by slow strain rate technique (SSRT) using a computer controlled constant extension rate test (CERT) machine (M/S CORTEST Inc, Ohio, USA) conforming to ASTM G 129-95 standard. Tensile specimens for SSRT test were machined out and prepared from the long transverse (LT) direction of the alloy sheet as per the ASTM E8-1983 standard. Tests were performed at an initial strain rate of ~ 3.3 X 10^{-6} s^{-1} in laboratory air and in naturally aerated aqueous 3.5 wt. % NaCl solution. In the present investigation, the authors have presented the SCC susceptibility index (I_{SCC}) by ductility ratio (*DR*), the ratio of strain to fracture in environment to strain to fracture in air ($\varepsilon_{envn}/\varepsilon_{air}$), fracture energy ratio (*FE*) i.e. the area under the plastic region of the stress strain curve in environment to the area under the stress strain curve in air (FE_{envn}/FE_{air}) and time to fracture ratio, i.e. time to failure in environment to the time to fracture in air (t_{envn}/t_{air}). In general, the higher the value of *DR*, the higher is the resistance to SCC.

3. Results and discussion

Fig. 2 shows a few representative stress–strain curves of the 7150 alloy of various tempers tested in SSRT unit in air and in 3.5 wt.% NaCl solution. SCC index (Iscc) values of the 7150 alloy of various tempers are listed in Table 5.

From the SSRT results and data, it can be concluded that the SCC susceptibility for the 7150 alloy is more in case of T6 temper as compared to HTPP aged and T6I6 temper. Further, SSRT results indicated that the novel ageing techniques (i.e. HTPP aged and T6I6

Table 3. Solution treatment and ageing schedules for the7150 aluminium alloy.

Alloy tempers	Solution treatment and ageing schedules
T6	Specimen were solutionised at 475 °C for 45 minutes, water quenched, followed by artificial ageing at 120 °C for 24 h.
HTPP	Specimen were solutionised at 475 °C for 45 minutes, cooling to 440 °C in furnace at a cooling rate of 1 °C minute and maintaining for 30 minutes for pre-precipitation, then water quenched, followed by ageing at 120 °C for 24 h.
T6I6	Specimens were solution treated at 475 °C for 45 minutes quenched in water, pre-aged or under aged at 120 °C for 30 minutes and again quenched in water. The water quench specimens were further aged (secondary ageing or secondary precipitation) at a low temperature of 65 °C for 10 days followed by re-ageing isothermally at 120 °C for 24 h.

Table 4. Chemical compositions (wt. %) of the 7150 alloy

Alloy	Zn	Mg	Cu	Zr	Fe	Si	Mn	Al
7150	6.30	2.40	2.30	0.12	0.10	0.05	NIL	Balance

aged) applied to the 7150 alloy have beneficial effects with enhanced resistance to SCC in 3.5 wt. % NaCl solution, without any significant loss of strength value. This is attributed to the variation of microstructural features which will be explained and discussed in subsequent paragraphs (SCC mechanism section) with the help of the microstructural features assessed by TEM.

Fig. 3a, the fractographs of the T6 temper tested in 3.5 wt.% NaCl solution exhibit prominent intergranular cracking, fine secondary cracks and very fine numerous dimples in some of the grains. However, the overall fracture surface looks like a rock candy type brittle intergranular appearance. Fractograph reveals mostly intergranular fracture surface leading to intergranular stress corrosion cracking (IGSCC) attack and brittle failure. When the HTPP aged specimen tested in 3.5 wt.% NaCl solution, the fractograph displays dimples in the interspersed grains which indicate ductile fracture and presence of a few and short intergranular cracks as well (Fig. 3b). The fractograph of the T6I6 temper tested in 3.5 wt.% NaCl solution (Fig. 3c) displays mixed-mode type fracture features. There are no signs of intergranular cracking, distinct cleavage facets (barring a few grains showing such features); however dimples of various sizes are visible.

Thus, from the observations of the fractograph evidences and features, it can be inferred that HTPP aged and T6I6 tempers have higher resistance to SCC compared to T6 temper, which is in good agreement with the observed slow strain rate test (SSRT) results.

4. Stress corrosion cracking mechanisms in 7150 alloy

The η ($MgZn_2$) precipitates located along the grain boundaries of 7xxx series Al-Zn-Mg-Cu alloy are more electrochemically active than the matrix. When the alloy and or the alloy tempers are exposed to corrosive environment, the η precipitates preferentially dissolve due to the

Table 5. Stress corrosion cracking index (I_{scc}) values of the 7150 aluminium alloy of various tempers tested by slow strain rate test (SSRT) technique in air and in 3.5 wt.% NaCl solution.

Temper	Environment	SSRT data			SCC index		
		% Strain to fracture, ε	Time to fracture, t_f, hour:min	Fracture energy (FE), J/cm^3	$\varepsilon_{env} / \varepsilon_{air}$	$t_{f\,env} / t_{f\,air}$	FE_{env} / FE_{air}
T6 aged	Air	9.35	14:00	38			
	NaCl solution	6.58	9:15	24	0.70	0.66	0.63
T6I6 aged	Air	11.76	16:00	47			
	NaCl solution	10.51	15:10	44	0.90	0.94	0.93
HTPP aged	Air	14.61	18:10	66			
	NaCl solution	11.13	17:30	64	0.96	0.93	0.96

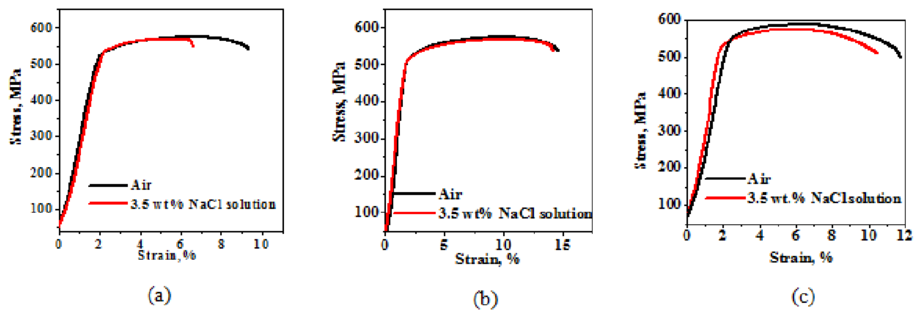

Figure 2. A few representative stress–strain curves of the 7150 alloy of various tempers tested in air and in 3.5 wt.% NaCl solution (a) T6, (b) HTPP and (c) T6I6

Failure is success if we learn from it. **Malcolm Forbes**

galvanic reaction between the η precipitates and adjacent alloy matrix and results in an active corrosion path. In the present study, the TEM micrographs (Fig. 4a) of the 7150 alloy of the T6 tempers revealed that the η ($MgZn_2$) precipitates are continuously distributed along the grain boundaries. During the slow strain rate testing (SSRT) of the T6 alloy temper in the test media, the η precipitates present in the microstructures of T6 tempers undergo preferentially dissolved by the said galvanic action. Thus, the galvanically corroded regions (i.e. dissolved continuous precipitates) under the applied increasing loading during SSRT acted as crack initiation sites and crack propagation path as well, resulting in intergranular stress corrosion cracking (IGSCC). So, local (intergranular) anodic dissolution is proposed to be one of the operating models for SCC failure in the T6 temper of the 7150 alloy. Similar mechanism has also been proposed in literature [8-10].

However, stress corrosion (SC) crack velocity depends on the rate of dissolution of the anodic η precipitates. So, a larger size and wider spacing of these precipitates decrease the dissolution rate, slower down the crack propagation velocity and improves the SCC resistance of the alloys. In the TEM micrograph of HTPP aged alloy (Fig. 4b) the larger, discrete and discontinuous distribution of η precipitates along the grain boundary did not act as favorable galvanic action between anodic η precipitates and matrix, and hence there is no appreciable and significance intergranular galvanic corrosion. This inhibited and delayed crack initiation and propagation exhibiting enhanced resistance to SCC. Further, the TEM micrographs of T6I6 temper (Fig. 4c) show that the grain

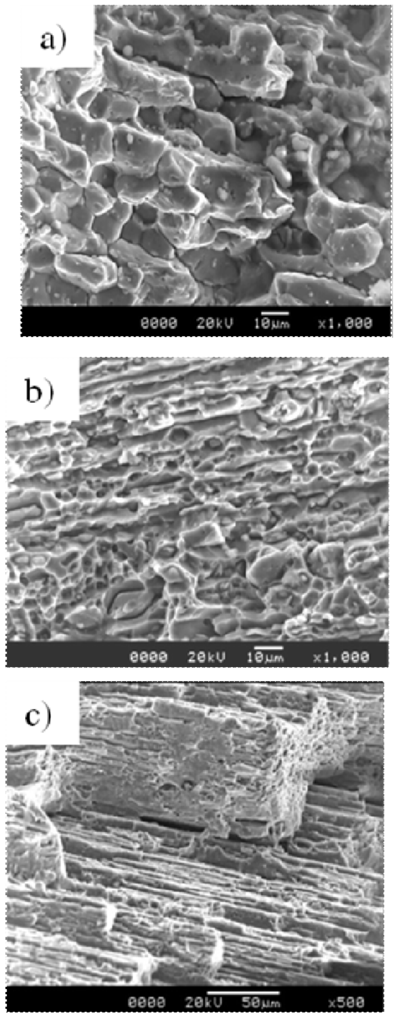

Figure. 3. SEM fractographs of SSRT specimens of the 7150 alloy of various temper tested in 3.5 wt.% NaCl solution (a) T6 (b) HTPP (c) T6I6

Winners lose more than losers. They win and lose more than losers, because they stay in the game. "
~ Terry Paulson

OLD ARCHITECTS never die, they just lose their structures

boundary precipitates are very fine compare to that of T6 temper but at the same time these are discrete and discontinuous. Thus, these novel heat treatments (i.e. HTPP and T6I6) applied to the 7150 alloy have caused in alteration of microstructural features of the alloy.

4. Conclusions

The mechanism more probable to induce SCC in the 7150 alloy of T6 temper is anodic dissolution of grain boundary precipitates. The resistance to SCC of the high temperature pre-precipitation (HTPP) aged and interrupted ageing (T6I6 aged) tempers is attributed to the non-interconnected nature of the grain boundaries η precipitates. Thus, the present investigation represent that microstructural features of the 7150 alloy tempers have changed by different novel ageing treatment (i.e. HTPP and T6I6) and effectively improved the SCC resistance of the while retaining the peak aged strength property.

5. References

[1] N. Moriber, Corrosion Basics: An Introduction, 2nd Ed. Pierre R. Roberge (Houston, TX: NACE Int., (2006), 394-395.
[2] S. J. Findlay, N. D. Harrison, Materials today, November, (2002), 18-25.
[3] Z. Huda and P. Edi, Mater. Des. 46 (2013), 552–560.
[4] J.C. Williams and E.A. Starke Jr., Acta Mater. 51, (2003), 5775–5799.
[5] M.B. Kannan and V.S. Raja, Eng. Frac. Mech. 77, (2010), 249–256.
[6] Y. Deng, Z. Yin, K. Zhao, J. Duan, J. Hu and Z. He, Corros. Sci. 65, (2012), 288–299.
[7] P.K. Rout, M.M. Ghosh and K.S. Ghosh, Mater. Sci. Eng. A 604, (2014), 156–165.
[8] M. Czechowski, Adv. Mater. Sci. 7, (2007), 13–20.
[9] D. Najjar, T. Magnin, T.J. Warne, Mater Sci Eng A 238, (1997), 293–302.
[10]R.G. Song, W. Dietzel, B.J. Zhang, W.J. Liu, M.K. Tseng, A. Atrens., Acta Mater 52, (2004), 4727–4743.

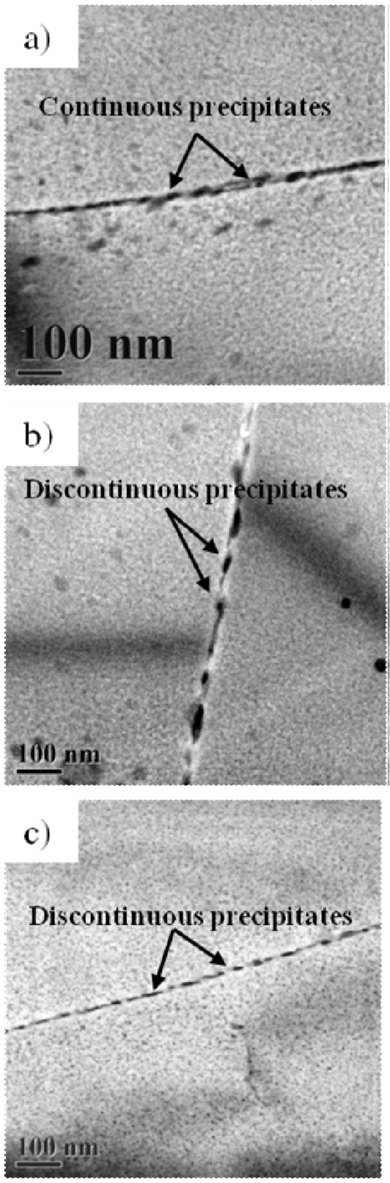

Figure.4. TEM microstructures of the7150 alloy of various tempers (a) T6, (b) HTPP and (c) T6I6; detailed discussion in see section 4

Lessons from Structural Failures in India

Dr S R Satish Kumar
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The objective of Forensic Structural Engineering is to trace the path which led or could lead to a failure and suggest suitable methods to avoid it. There are a number of reasons for structural failures in India. These may be listed as follows:

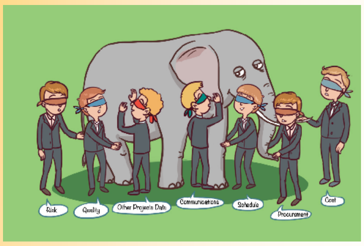
1. inferior quality of the educational system in several institutions.
2. lack of a regulatory mechanism such as a license for practice for engineers and technicians.
3. Inefficient and unjust legal framework.
4. barrier between a literate and an illiterate worker.
5. adoption of new materials and systems.
6. inadequate and unreliable material testing facilities.
7. Inability to learn from extreme events such as cyclones and earthquakes.

The first case study is concerned with the simple compound wall where two different failures occurred over a period of time. In the first case, a large length of a compound wall overturned on a hot summer afternoon and investigations proved the cause to be the light weight nature of the wall due to the use of hollow concrete blocks. Since there was no high wind recorded during that time, it was probably a whirlwind which develops during the hot summer which must have pushed the wall. Normally, an equivalent solid brick wall of that height would not have overturned under such conditions due to its inherent weight. Hence, the mason who was used to build brick walls had not expected the wall to overturn. In the second case, a strong wall of random rubble masonry, about two kilometers long and two meters tall, was built but its enormous weight became a drawback as it was pushed by a strong earthquake.

The next case is that of a cantilever scaffolding for a bridge which had a critical weld at the top. Two sets of systems were shop fabricated and the weld quality was checked by ultrasonic testing. However, in order to speed up the construction, a third set was fabricated at the site and the weld gave way under the weight of the wet concrete.

With the advent of major pre-engineered building companies set up with foreign collaboration, most industrial buildings are being designed in stark contrast to the traditional trussed roof on built-up column systems. Both rafters and columns are designed as fabricated plate girders with deep thin webs. Lateral support in the minor axis direction is usually provided by braced bays using tubular struts. However, in one building, cables were used as bracings and the cables were not adequately pre-tensioned. As a consequence, under working loads the columns had a marked buckling about their weak axis.

In another incident, the rafters in a gabled portal frame were designed assuming them to be laterally supported and adequate roof bracing and strut tubes were provided to ensure stability for adjacent frames. However, after erecting two frames,



due to owner regulations to cease construction activity after sunset, the bracing could not be erected. The rafters were given temporary supports with guy cables anchored to the ground away from the frame line. During the night there was a light wind and in the morning, it was noticed that the rafters had undergone severe lateral torsional buckling under the combined action of wind and its own self weight. Even the columns had undergone a twist and damaged the pedestals. Apparently, the guy cables were not stiff enough to restrain the rafters from buckling. The incident underscores several points.

- Design should not be pushed to the limit where a slight increase in the load can lead to failure.
- Designer has to foresee possible loads during erection and also should specify erection procedures where possible.
- Safety regulations at site are intended to avoid injury to people and may not consider damage to structure or equipment. Where necessary, they should also consider damage to the structure since a damaged structure poses a greater risk for injury.

An aircraft Hanger roof collapsed during construction. The investigations into the cause started with the design document. It was observed that as is often the case, the steel hanger roof was designed by one consultant and the reinforced concrete supporting structure, along with the adjacent buildings were designed by another consultant. The first consultant had assumed simply supported conditions and given only axial loads on columns for design by the second consultant. Neither of them gave details of the steel truss support and so the contractor tried to avoid the use of separate anchor bolts and instead relied on the column reinforcement bars to hold down the truss. The consequent horizontal pull exerted by the truss led to the collapse of the roof. This underscores the need for a single structural engineer to be made responsible for the entire design and detailing.

A long, standing-seam roof system was installed over an industrial structure and one fine day, a part of the roof was blown off. There were several temporary structures such as huts with palm leaves which did not have any damage testifying to the fact that the wind velocities were normal. Rechecking of the design calculations showed that the roof was designed to withstand code wind velocities which were much higher. After inspecting the site, it was realized that the clips used for clamping the roofing sheets to the purlins had opened up. The clip consists of two parts, one with a slot which is screwed dorn to the purlin using self-tapping screws and the other with a u-bent plate which is welded to the roofing sheet and engages with the slot. When held in the hands and disengagement was attempted, it was realized that a slight twist of one relative to the other facilitated the disengagement. Such a twist was not possible since one part was welded and the other part was attached with three screws. However, a closer look at the failed clips revealed that this was indeed the case as only one screw was installed thus allowing the wind to slowly twist the clip with each gust and also to loosen the screw.

A large number of structures collapsed during the Gujarat earthquake of 2001. Investigations revealed the following major reasons (Earthquake Spectra 2002):

- Neglecting the contribution of the wall stiffness resulted in several open-ground storey buildings failing by the soft-storey mechanism.
- Many design engineers were unaware of a code on ductile detailing of RC structures (IS13920:1993) and had designed and detailed as per the basic design code (IS456:2000).
- poor understanding of the dynamic response of the systems.
- Poor quality materials and poor quality workmanship were revealed by the seismic load.

There have also been several fire disasters in India and although codes on fire design and fire protection are available, their implementation is difficult to ensure.

During a recent cyclone HudHud in the east coast of India, the Visakhapatnam airport was severely damaged. The exact cause of the damage is being investigated but it may be observed that architecture involving large glass curtain walls are vulnerable during extreme winds and may not be suitable in tropical countries.

In conclusion, it may be observed that there are several factors responsible for the relatively large number of structural failures in India and these need to be addressed to mitigate loss of life and property. The development and popularization of Forensic engineering as a subject can raise awareness about these problems and help steer the concerned people in the right direction.

Specific case studies if made available on the internet can help in others learning the lessons from past failures and thus avoid the pitfalls judiciously.

References:

Satish Kumar S. R. ‘Lessons from structural failures in India’, Forensic Engineering, Institution of Civil Engineers, UK, Volume 169 Issue 4, November 2016, pp. 143-148.

Failure Analysis in Metallurgical Industries –FAME-2017

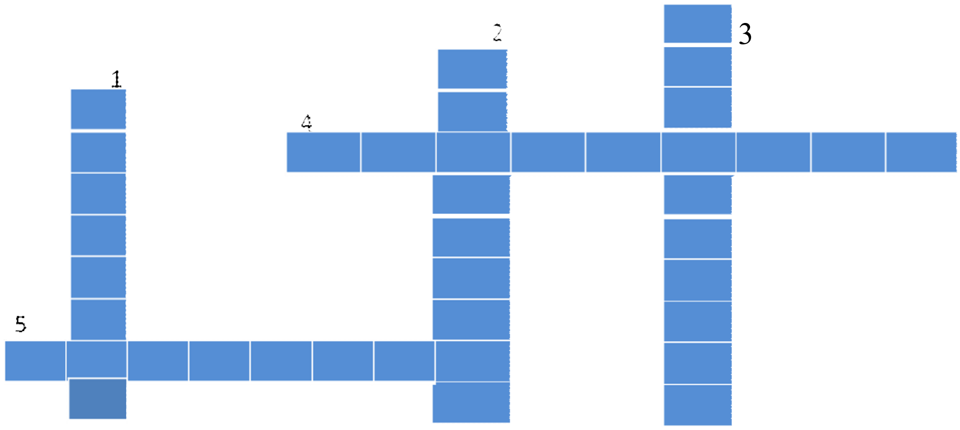
Society for Failure Analysis (SFA), Hyderabad Chapter jointly with Defence Metallurgical Research Laboratory (DMRL) and Regional Centre for Military Airworthiness (Mat), Hyderabad conducted a one-day Seminar on "Failure Analysis in Metallurgical Industries (FAME-2017)" on 5th August, 2017 at Hotel Minerva Grand, Secunderabad.

Dr. Samir V. Kamat, OS & D.G. (NS&M), DRDO and Shri N. Ranga Rao, CMD, Sai Deepa Rock Drills graced the occasion as Chief Guest and Guest of Honour, respectively. Shri.Satyapal Singh, Scientist G & Group Head, SFAG, DMRL welcomed the gathering and briefed on the genesis of the seminar as well as its technical deliberations. Dr. Vikas Kumar, OS & Director, DMRL stressed on the importance of failure analysis in the metallurgical industries and highlighted the contribution of DMRL in such activities over the past three decades. Shri P.Jayapal, President, SFA and CE(A), CEMILAC, Bengaluru appraised the gathering about the functioning of SFA and its effective utilization by the engineers, technologists, scientists and others. Seven invited talks were delivered by the eminent experts from the R&D organizations, academia and industries covering the entire spectrum of seminar theme involving failure analysis methodology, role of NDT in failure analysis and failures in aerospace & defence industries as well as other metallurgical industries. Dr. Chandan Mondal, Scientist E, DMRL, Convener, FAME-2017 and treasurer, SFA Hyderabad chapter proposed the vote of thanks. About 110 delegates from industries, academia and R&D organizations participated in the seminar actively and got benefitted. On this occasion, the society also felicitated Dr. Kamat, Dr. Vikas Kumar, and Shri Jayapal on being promoted and/or assuming higher responsibilities in DRDO. The society conferred the inaugural SFA awards namely, the National Failure Analyst 2016 to Dr. Chandan Mondal and Dr.P.Parameswaran and the Lifetime Achievement Award 2016 to Dr. A. Venugopal Reddy.


Cross word puzzle on failure analysis terminology

1.O! spy roti for its openness [8]
2. Gear sink in H-lubricant exhibited reduction in size [9]
3. I alongwith fifty interrogated tacit spy who exhibited yielding [10]
4. River got into small company-so aggressive chemical action [9]
5.Operation of introducing gas in tin reduced its MP and made workable [8]

See page 17 for answers:



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5.Operation of introducing gas in tin reduced its MP and made workable [8]

Society for Failure Analysis

Application Form

Society for Failure Analysis
C/O Centre for Military Airworthiness & certification, RCMA (Materials)
Hyderabad550 058

Phone: 040-24340750; 24348377;
Fax : 040-24341827
E-mail: rdrcma.mat@cemilac.drdo.in

Please √ applicable **member** ☐ **Life Member** ☐

1. **Name in Block Letters**

First Middle Last

2. **Date of birth**
3. **Father's Name/ Husband's Name**

4 **Present Occupation /Designation and office address:**	**Phone:** **Mobile:** **Fax:** **Email:**

5 **Academic & Professional Qualifications**:

6 **Home address:**	Phone: Mobile: Fax: E-mail

6. **Address for correspondence:** **office** ☐ **Home** ☐

7. **Professional Experience**:
8. **Endorsement by SFA Member**

Name	Membership No.	Signature

9. **Primary Field of Interest: (please mark 1,2,3 in the in order of preference**)

Strategic ☐	Power ☐	Foundry ☐	Welding ☐	Heavy industry ☐	transport ☐
Design & Failures ☐	Quality control ☐	Petrochemical ☐	Consultancy / services ☐	Materials and manufacturing	Education ☐

10. **Name of the Chapter you intend to be attached**____________________________
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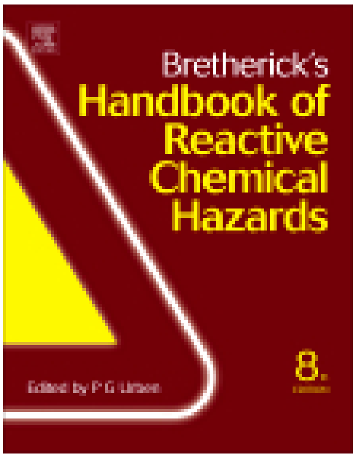
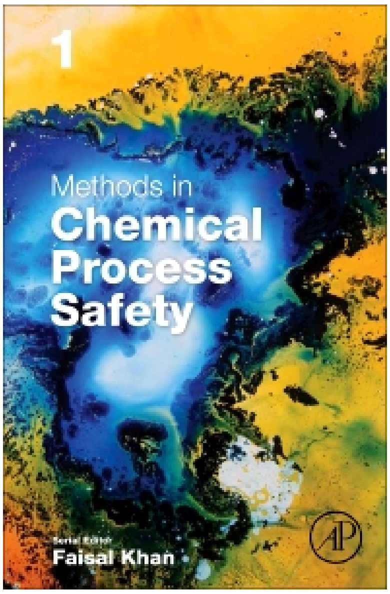
Books



Handbook of reactive chemical hazards:
Edited by Peter Urben
Presents the latest updates on the unexpected, but predictable, loss of containment and explosion hazards from chemicals and their admixtures and actual accidents. The extensively cross-referenced book enables readers to avoid explosion and loss of containment of chemicals.
Editors: Peter Urben
Imprint: Elsevier
Published Date: 24th March 2017
Page Count: 1520

Series: **Methods in Chemical Process Safety**



Methods in Chemical Process Safety publishes fully commissioned methods papers across the field of process safety, risk assessment and management and loss prevention. It aims to provide informative, visual and current content that appeals to both researchers and practitioners in process safety. Publishing one themed volume a year, the publication will provide a resource detailing the latest methods in the field of chemical process safety.

The series will cover the following topics:
Hazard identification and detection:
Hazard identification including atypical hazard identification
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Risk Assessment and Management:
Risk assessment and management including dynamic risk assessment and management , operational risk management, and risk based design

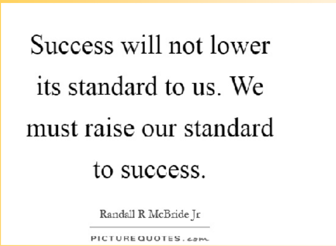
Defining Risk Acceptance Criteria
Risk Assessment with Limited Data

Events in the pipeline

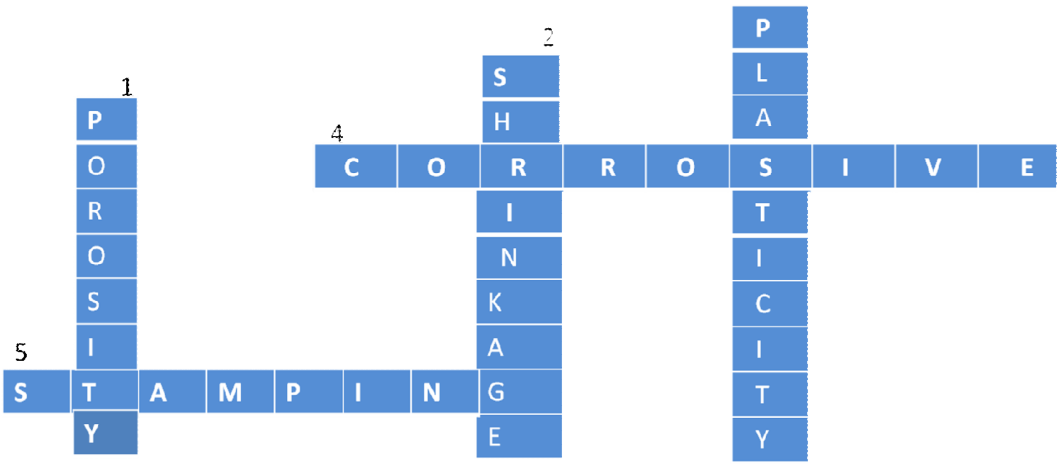
2nd International Conference on Engineering Design and Analysis (ICEDA 2017): Conference Dates 13 - 15 Oct 2017: http://www.iceda.org/index.html

SFA-IIM joint symposium on failure analysis during NMD-ATM 2017 of Indian Institute of Metals at BITS, Goa during Nov.11-14, 2017: details in the web:

http://www.nmd-atm.org/index.php



Answers to the crossword:



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