



JOURNAL

of

THE ASSOCIATION OF ENGINEERS, INDIA

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THE ASSOCIATION OF ENGINEERS, INDIA

(Estd. 1919)

(Society Registration no. S/4849 of 1923-24)

HQ : 24, Netaji Subhas Road, Kolkata-1, Tel : 2230-6714

Continuing Education & Training Centre : IA-11, Salt Lake City,

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Council Members : 2007–2009

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44.	Er. Sanjib Mandal	Member (M)	08. 08. 02
45.	Er. Sanjoy Kumar	Member (M)	30. 11. 01

FROM THE PRESIDENTIAL DESK:

An Ode to Nature

The day Comes. It bringeth the wind of joy, the sea of sorrow, the deluge of devastation!
The day crawls. Humans invoke it in their race for a quality & prosperous life!

The day laughs. What is the definition of a quality & prosperous life ! Is it percapita Consumption of Steel, Cement, Energy a year? Is it what quantum of goods & services Humans consume in excess of that required for a decent living?

The day smiles. It takes a compassionate look at the things happening around. It chants repeatedly, "You don't produce anything; all you do is, you transform the nature's gift to your usable form.

The day sighs. Humans think that they have conquered the nature. They find nothing wrong in ruthless exploitation of the natural resources to satiate their greed for grabbing more and more.

The day warns. There come the Tsunami, the ghastly wind, the forest fire, the devastating flood, the resurgence of the deadly diseases in deadlier forms, the unforeseen draught, the hole in the Ozone layer, the unpredictable weather, the tremendous tremour resulting in the ecological imbalance the world over.

The day rejoices. Human jumps into the relief work. The day feels Humans will take a lesson.

The day sinks with a heavy heart. Humans with renewed vigour eye on the weaponry to invade and dominate others.

The day rings a warning bell. Polar ice melts. Climate warms. Sea level rises. Natural resources near extinction.

The day puzzles. Humans are so foolish! They want to demarcate waters, air and soil!

The day weeps. Civilization awaits total devastation; the day silently witnesses the impending deluge.

The day is no more gloomy. A new civilization with better enlightenment will dawn. It will be in total harmony with the mother planet of theirs. There will be roses roses all the way and no thorn.

The day exhorts, the day chants the **PSALM** of the renunciated life.

Om shanti, Om shanti. Peace Peace everywhere.

Prof. Dr. M. Bhattacharyya

ASSOCIATION NEWS

Activities

✦ A novel modular Training Programme on 'Rainwater Harvesting:Design and Estimation Module' backed by experimentation for the first time in Eastern India in different phases, was conducted successfully on 20th April,2007 with twenty (1st phase) and on 29th June,2007 with 18 participants (2nd phase) . The second training programme (1st & 2nd phases organized on 28/09/07 & 29/09/07) with eighteen participants. Two prototype rainwater harvesting structures have been constructed at the Association's premises for demonstration purpose and also to spread awareness among participants about harvesting techniques.This will also send a signal to the

visitors that rainwater harvesting can be taken up and implemented successfully by them for their households / offices / residential colonies. The programme was attended by representatives of Municipalities, Realtors, Universities and Individual students.



Inauguration of First Rainwater Harvesting (RWH) Training Programme (L-R) Prof Shyamal kanti Sanyal, Vice chancellor, Jadavpur University, discussing with Prof Dr Madhusudan Bhattacharyya, President, AEI prior to inauguration.



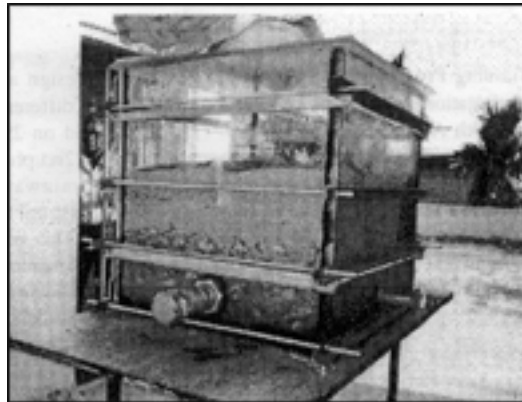
A section of the participants at the above programme. 2nd from right (1st row): Prof Dr. Balaram Bose, a distinguished faculty.



Dr. Nikhil Ranjan Banerjea, Vice chancellor, BESU addressing the participants of the above RWH programme.



Prof Dr Madhusudan Bhattacharyya, President, AEI inaugurating the 2nd RWH Training programme



Experimental set up for RWH at the Association's premises at Salt Lake.

- A prototype Rainwater Harvesting structure for Civil Engineering Building at Jadavpur University campus in collaboration with Jadavpur University is almost finalized. A full fledged Rainwater Harvesting Structure is shortly coming up in a rural school, Jhapordah Duke Institution, Howrah, sponsored by the Association.



A view of Jhapordaha Duke Institution, Howrah where the Rainwater Harvesting Structure is sponsored by AEI

- ♣ Different companies were approached for conducting Campus Interviews for the students of different courses namely Diploma in Safety Engineering, Construction Supervisor 'O' & 'A' levels and Amin Surveyor run by the Association; all the courses are affiliated to the West Bengal State Council of Technical Education. M/S HCC, GAMMON INDIA, ITD CEMENTATION, SIMFT, SHAPOORJI & PALLONJI AND GANNON DUNKERLY etc are regularly recruiting our boys either on campus or off campus: 100% placement has been completed. All the students passing out from the Association in previous years are in employment.
- ♣ A renowned homeopath oncologist is attending free clinic at the Training Centre of our Association every Wednesday.
- ♣ We have instituted 'Jayanta Choudhury Memorial Medal' for the first boy of the Diploma in Safety Engineering course from session 2006-07 onwards.
- ♣ We are giving freship or one time grant to the deserving students of different courses and an account is being separately maintained. for this purpose.
- ♣ Eight meetings of the Executive Council were held during the year 2006-07
- ♣ The 87th Annual General Meeting was held on 23-06-07 at 6-30 pm at the office of the Association at IA-11 Salt Lake, 700 097 with Prof (Dr.) Madhusudan Bhattacharyya on the chair. The members present deliberated on agenda-points followed by adoption of unanimous resolutions.



87th Annual General-Meeting held 18.06.2007 (L-R) Sri Chittaranjan Haldar, Secretary. Prof Dr. Madhusudan Bhattacharyya, President, Prof. Dr. Rajat Chakraborti, Immediate Past President.



General Members attending the AGM

- ♣ Dr. J. N. Kanjilal's birthday was celebrated on 31/08/07 by Institute of Hydt Research and Education in collaboration with AEI.
- ♣ Coverage of Training Programme on Rainwater Harvesting by the **Print & TVmedia**
-The Statesman reported about our programme on 20/05/07, 30/06/07, 22/07/07.
-The Telegraph reported on 30/07/07
-ETV telecast our Training Programme on 30/07/07.
-Doordarshan, Kolkata telecast our programme on 28th August, 2007.
-Akash Bani broadcast our programme
- ♣ Next executive council meeting will be held on 22nd February, 2008 at 6.00 p.m. at Association's Training Centre at IA-11, Salt Lake, Kolkata-700 097.
- ♣ Results of DSE examination for the session 2006-07 is likely to be out in Nov'07.
- ♣ One hundred students are pursuing DSE course for the session 2007-08 & their examination will be over by mid-June: all the Corporate Sectors of Manufacturing & Construction Industries come for interview at our campus.



Classes on Construction Supervisor/ Diploma in Safety Engg in progress. Sri Chittaranjan Haldar delivering lecture.

- ♣ Fifteen students are pursuing Construction Supervisor 'A' level for the session July-December, 2007 and their examination will be over by January, 2008. We invite Corporate Sectors and other companies of Construction Industries to come for campus interview.
- ♣ We would like to bring out a special issue of our Journal on Construction Safety wholly dedicated to the student. We request the Head, HSE of all corporate sectors of construction industries to contribute articles by April 21, 2008.
- ♣ Dr. Sunil Ranjan Bandopadhyay, our life member, wishes to donate quite a few books on Power Engineering (Electrical) in Russian Language. Interested person may contact him at Flat-2, Block-20, 131, NSC Bose Road, Kol-700 040.
- ♣ Our Institute is planning to construct rainwater harvesting structures in rural area schools having neither access to water nor funds. We solicit generous sponsor from benevolent public.
- ♣ 95th Indian Science Congress was held in Andhra University, Visakhapatnam on January 3 through January 7, 2008. For the first time in the history of the Science Congress, a session was devoted to Homoeopathy under Medical Sciences (including Physiology) on

January 6, 2008. Our member Dr. Ashoke Kumar Pradhan (life Associate) chaired the session.



Dr. Pradhan (left) is being awarded a memento.

- Dr. Ashoke Kumar Pradhan was invited to Tea at Rajbhavan on January 26, 2008 for his continued social work being carried out through Institute of Hyde Research & Education in collaboration with The Association of Engineers, India.



- Dr. Pradhan is seen with Sri Siddhartha Ray, Ex-Chief Minister of WB, Sri Buddhadev Bhattacharyya, Hon'ble Chief Minister, WB and Hon'ble Sri Gopal Krishna Gandhi, Governor of West Bengal.

Our President Prof Dr.Madhusudan Bhattacharyya, was felicitated by Indian Society For Non-Destructive Testing, Kolkata Chapter for his pioneering and path breaking contribution to Indian Society For Non-Destructive Testing & Non Destructive Testing Profession in a Colourful Ceremony held on November.24, 2007 at ISNT'S newly acquired own building at Ballygunge, Kolkata. Incidentally Prof Bhattacharyya, was the Chairman of the Chapter for more than a decade till 2005.

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Synopsis

Rainwater Harvesting

Presented by Prof. Dr. Madhusudan Bhattacharyya, President & Shri Chittaranjan Halder, Secretary on behalf of The Association of Engineers, India, IA-11, Salt Lake City, Kolkata-700 097, Website : www.aeihqcal.com

[Presented at the Chapter Convention on Quality Circle, CCQC-2007 (Silver Jubilee Year of QCFI) at Taj Bengal]

1. INTRODUCTION

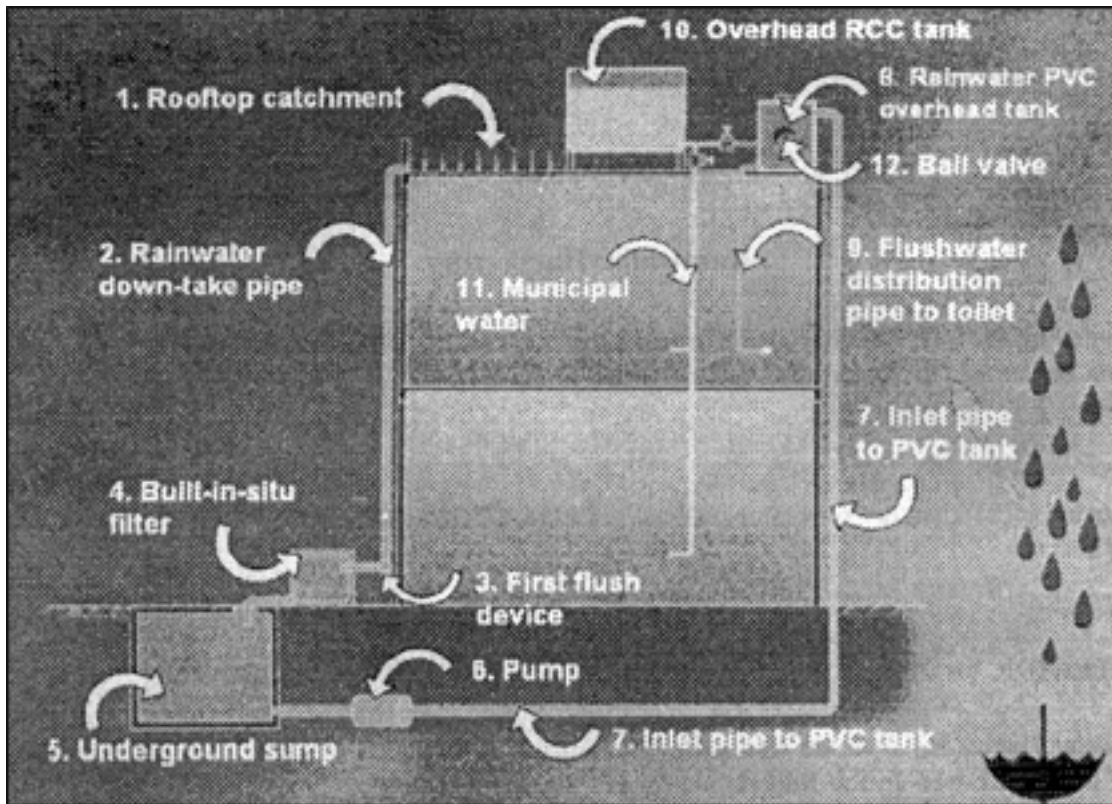
Rainwater Harvesting must be resorted to by humans to take care of fastly Depleting potable water the world over. In the Kolkata metropolis the water table has gone down by 7m to 11m in the last 49 years. According to International Water Management Institute, Colombo, by 2025 all the known sources of freshwater are believed to be exhausted. It is predicted that the next world war will be over water.

WHAT IS RAINWATER HARVESTING?

It is simply a method of capturing rainwater where it falls, store it in a reservoir, surface or underground and/or recharge the underground aquifer and use it in the hours of need.

WHAT HAS BEEN DONE BY THE ASSOCIATION?

Rain water falling on a portion of the roof-area of the Association's Building is stored in a 6600 l underground resevoir and the same is pumped (automated system) to a secondary tank (rainwater tank) placed on the rooftop which has been providing flushing water for the last 5 months.



[fig. 1]

We have plans to recharge the underground aquifer by the rain water falling in excess of our reservoir capacity for which we have applied for permission of the competent authority.

WHAT ABOUT THE QUALITY OF RAINWATER?

Rainwater is collected after expunging the rainwater for a few minutes of shower.

Rainwater sample from the underground rainwater reservoir and that supplied by Bidhannagar Municipality were tested by a renowned test house; it has been reported that rainwater is superior to municipal supply. In the light of that report we are planning to harvest rainwater for drinking and cooking in rural areas

WHY RAINWATER HARVESTING IN KOLKATA?

Kolkata Municipal Corporation (KMC) supplies 320 Mgd (million gallons per day) (290 Mgd from Hoogli river and 30 Mgd from the underground aquifer) against a demand of 334 Mgd (Year2004). In addition various bodies withdraw 441Mgd from the underground aquifer whereas 45 Mgd, hardly 10% of the withdrawal is getting a natural replenishment apparently creating no headache in the society.

Shall we leave the city reeling under acute water scarcity for the posterity as with time river will also go dry?

SO RAINWATER HARVESTING IS A MUST.

WHAT THE ASSOCIATION OF ENGINEERS, INDIA IS DOING?

It has pioneered training programme backed up by the experimental facility in the Eastern India designed as a Finishing school; the trained personnel would be able to visualize the best rainwater harvesting system location-specific, design, supervise construction work, run and maintain the system.

THE ASSOCIATION ACTS AS A FACILITATOR.

Why will the people go for taking additional pain to construct rainwater harvesting structure when by the turn of a tap, water is available aplenty? Remember that municipal supply is not evenly distributed throughout the city; a portion is affluent in water while the rest are reeling under water crisis. Even by KMC's own estimate the amount of water wasted by way of transmission, distribution and stand-posts cost the authority a staggering amount of 65 crores of rupees a year. By bringing down the wastage and taking to rainwater harvesting, depletion of underground aquifer can be substantially retarded.

All said and done, man by nature is self-centric. Therefore the Association suggests that the following incentives be given for motivation.

- a) All new constructions must incorporate Rainwater Harvesting to be ensured by appropriate legislations.

Withdrawal of groundwater without permission has been banned by legislation. But the law should be ensured by appropriate monitoring and enforcing authority.

- b) A rebate in fees to be paid for sanctioning construction plans.
- c) A subsidy be given to meet up part of the cost towards rainwater harvesting structures in line with what is followed for promoting the use of renewable sources of energy.
- d) A rebate be allowed in property tax to the tune of 10%.
- e) Water meter be installed at all user points.

After all, all the public bodies are equally accountable for maintaining the ecological balance.

Conclusion

The 2nd Finishing School on Rainwater Harvesting was held on September 28 & 29, 2007. For further details please visit our website: www.aeihqcal.com

INTERLINKING OF RIVERS : SOME ASPECTS

Balaram Bose, Fellow

Former Professor & Director, School of Water Resources Engineering,

Jadavpur University, Kolkata 700032, India, e-mail: bb_wre@rediffmail.com

1. BACKGROUND

Things are not going well in the water sector in the country since the past few decades. Every time the country is entrapped with some crisis in the water sector, the Think-Tank of the Ministry of Water Resources (MOWR), apparently the sole custodian (?) of the water wealth of the country, come up with some new strategy or policy or formula or scheme. This new arrangement or scheme is usually projected as more effective and brighter and more striking than the earlier ones being the answer to the emerging crises and ills and adversaries prevailing in the water sector at that time. In the absence of accountability and transparency, the two most important, if not vital and inseparable aspects of development and sustainable growth, a common routine scheme can even be publicized and blown up as a visionary one! The practice has become rather a common way to avoid crisis or to shake-off responsibility, public criticisms and undesirable events and to shift to a new one pushing back or by-passing and/or ignoring the prevailing realities. Such a practice enjoy favour and patronage among bureaucracy and administration besides the political circles. There are no dearth of instances, at least, in the water sector in the country since the First Five Year Plan(1951-56). The 8th Plan Document (1992) had emphatically summed up the situation in unambiguous term in a single sentence which reads: “The biggest malady of this sector (i.e., water resources development—author’s note) right from the First Plan has been the continued tendency to start more and more projects resulting in wanton proliferation of projects, their spreading of resources and consequent time and cost overrun” (5b). As per official records a sum of over Rs.91,000 crores have been spent till 2000-01 for the construction of dams, reservoirs and irrigation structures and for their operation and upkeep. Unfortunately many of the projects are incomplete and some remained to be implemented as yet: and the performance of the functioning ones are unfortunately running far below the capacity. Various reasons namely, sectorial planning, defective choice of project sites, legal constraints, lack of concern on eco-environmental and social impacts, abuse of resources, resistance from the people displaced or ousted by the projects, disputes and conflicts among the competing interests, poor maintenance, techno-bureaucratic muddling, irregular flow of funds, etc., to mention some important ones and to surpass them all political intervention, if not compulsion, and planning lacuna have landed us in the chaotic and problematic state of affairs in the water sector today. It is often argued widely that many of the knots and riddles in the water sector have originated due to faulty and short-sighted planning. The Nation has no alternative but to bear them in the form of heavy subsidy to compensate chronic revenue deficit and generous loans (mostly unrealized(?) and/or written off) and recurrent relief to make up the high input costs and above all under performance of the prevailing infrastructures. The recent report of the World Bank-MOWR joint study published in 1999 has more or less substantiated the above observations. The report has further revealed that it would be difficult to sustain the prevailing benefits in the water sector for long if proper attentions are not paid towards the dams, reservoirs and other irrigation infrastructures, which happen to be the largest in the planet.

Besides, the problems in the water sector are further compounded by the ongoing disputes and conflicts over the share of a number of some inter-state rivers among the riparian provinces. The

available water in these rivers are hardly enough to meet the prevailing requirements not to speak of the rising additional demand. Again flow and quality of the most of the rivers in the country have also been declining over the years (1.). It does not require any expert analysis to observe the appalling conditions of most of the major rivers and their tributaries particularly during the long dry spell (viz. roughly 7 to 8 months) when a number of rivers suffer from “functional no-flow” to “no-flow” conditions (Annexure II) at some of their stretches for a few days, if not weeks, in a year (8, 10, 18).

In the backdrop of the above scenario arrived the year 2002 an important, if not a landmark year, in the annals of water sector in the country. The first quarter (namely , April) saw the publication of the revised version of the National Water Policy - formulated for the first time in 1987, a clear forty years after the Independence and that too at a time when the country had faced one of the worst droughts in decades. The policy document could identify the “Priority Sectors” of water use and remained silent on the issue of allocation for different sectorial uses. It has however stressed on strengthening and updating the data and information base and reiterated the issues again in the revised version published in 2002 (5a), roughly after fifteen years. Sometimes during the fourth quarter (eg. on Oct. 31,2002) the Apex Court of the country while pursuing a Public Interest Litigation(PIL) case concerning issues and problems related to water directed the Union Government “to work out the necessary modalities to link the rivers of India to control floods and droughts”. The Union Government on its turn grabbed the opportunity and worked out a project within a short time namely, by April 30, 2003 and a blue print of a scheme under the name of “River Linking Project” (Annexure I) had been prepared bypassing the urgent issues eg. programme on restoration and proper upkeep of the prevailing irrigation structures, completion of the unfinished projects and implementation of the undone ones in order to strengthen and energise the agriculture and to ensure the sustainability of the yields.

The new Project, i.e. the River Linking Project (or RLP in short), is many many times bigger and glamorous than all the previous projects in the water sector combined together . This super mega project without any parallel in the history of development is connected directly and indirectly with most of the major rivers and /or their tributaries spread over nearly ninety percent of the country’s area and involving almost one-sixth of the population of the planet. No single project had ever been associated and covered such a huge and widely varying physical, eco-environmental, demographic and socio-cultural diversities and complexities involving nearly ninetyfour percent (or about 1000 million as on 2004) people of a country.

The project (i.e. RLP) has portrayed a rosy picture in terms of benefits and other outcomes, a long lists of tall claims mostly exaggerated and unfeasible, apparently showing not much concern on the potential risks and uncertainties and untoward impacts and consequences on the physical, environmental, social, cultural, legal and economic fronts in particular and neglecting (?) the real costs to achieve all the benefits postulated. For instance, a large section of experts doubt if the RLP would generate such huge quantum (e.g. about 34,000 MW) of surplus hydro-power as claimed. It has further been attempted to convince the Nation that the RLP, if accepted and implemented, would mean almost ends of all ills and adversaries in the water sector in the country(7, 11a.) for present and also for future.

2. INTER-BASIN TRANSFER

In theory the inter-basin transfer of water from surplus basin in one area to water deficit basin in another region within the same or another country is potentially an ideal concept to address simultaneously the problems of flood and water scarcity or drought. The inter- basin water transfer as such is an act of defying and disrupting the natural geo-physical barriers (e.g. large lift, physical diversities, etc) and dislocation of the established drainage besides socio-economic and cultural traditions of the regions involved. For it is Nature that schemes the formation of a river and its drainage basin and subsequently establishes the physiographic divisions including the

water zones in a region spread over a single or multiple administrative jurisdiction within a country or several nations. Any work or scheme with a river (e.g. construction of structures across it, withdrawal and/ or diversion or transfer of water, etc) in the name of development would cause some impacts, desirable or unwanted, small or big, on the river and also in the eco-environmental fronts and its estuary and the riverine wetlands . In the long range perspective the decline of river flow would upset the established ecological balance and jeopardize the fishing and water transport and eventually the socio-economic set ups in these reaches. The physical regimes, eco-environmental features and even water quality of two or more rivers to be connected usually vary widely (14). Physical union between widely contrasting systems is generally detrimental to both the rivers and their basins. An unfortunate trend seems to dominate the water sector that the planners in most cases are guided by the idea of immediate gains or returns and overlook (or fail to recognize) the adverse, impacts, direct

and hidden, usually build up or grow rather very slowly in the early years. Again hardly any satisfactory or definite methods or ways to ascertain or understand the impacts of water projects on the physical and eco-environmental systems in particular are available to-day. The best or practical way under such circumstances is to go by historical evidence and to act or move in cautious and calculated manner such that appropriate steps to confront adversaries, if any, at any stage could be thought of at least theoretically.

Inter-basin transfer has been in practice in different parts of the world for quite some time. Experiences in USA, China, erstwhile USSR, etc are unfortunately not satisfactory. Now, the fallout of mega-planning that pays little or no heed to social and eco- environmental consequences would manifest in course of time in the form of various physical disruption, environmental degradation and. ecological damages in nearly disastrous, if not catastrophic scale, and subsequently would lead to the breakdown and disruption of the established life and activities of the population involved and eventually may cause economic ruin of the region. There are plenty of instances where such situations could be observed in different corners of the globe. The dying of the Aral Sea (an inland waterbody with an area of nearly 7.05 Mha) located in central Asia within the erstwhile USSR seems to be an important but unfortunate case in point. In their zeal to grow cotton in the semi-arid and aridic tracts arounds the Aral, the planners of the then Soviet Union during the mid 1950's planned large scale diversion of flow from the two rivers of the region namely, the Amu Darya and Syr Darya to irrigate the crop fields in the desertic tracts depriving the Aral of its natural regular replenishment. The action has triggered the process of decay of the Aral namely, depletion of water and receding of the shoreline. In a span of four decades or so the Aral has shrunken to more than quarter of its original area and transformed into several saline lakes devoid of biodiversities many of which were unique and commercially lucrative. At present the Aral, a heritage of the entire humanity, is awaiting death and would likely to be written off from the world map by 2020, if not early.

The story of the Aral has unfortunately not ended as yet. Economic activities (viz shipping, fishing industries, tourisms, etc) have totally collapsed leading to the disruption of life and activities and of the region. Vast areas in the five adjoining republics (namely, Uzbekstan, Turkmenstan, Kajikstan. Kyrgyzstan and Tajikstan) are continually being contaminated by the toxic sand blown from the exposed sea beds thereby affecting agriculture, vegetation, birds, animals and people. Toxicity of sand is caused by the accumulated residual pesticides and insecticides used profusely in agriculture expanded manifold after the availability of water. To-day thousands of people including infants and unborn babies are suffering from various unknown and incurable diseases and the region is also experiencing weather uncertainties. Nobody knows for certain when the sufferings of the unfortunates population would cease, if at all.

In the Indian context transfer from the so-called water surplus area to water deficit region as such is not completely new as stated above. Several schemes of inter-basen water transfer in much more smaller scale undertaken during the early years of the Colonial rule

from apparently water rich areas to water-starved areas within basin and beyond are still functioning. In the absence of systematic records it would be difficult to know exactly the adverse effects of those schemes.

During the post-Independent period several schemes on inter-basin transfer have also been undertaken of which the transfer of water from the Ravi-Beas through the Indira Canal to different places in Rajasthan would be worth mentioning. Historically several conceptual schemes namely, the Ganga-Cauvery Link, Garland Canal, Brahmaputra-Ganga Link, Linking Narmada to Gujarat, etc to augment the dry weather flow of the water starved rivers through transfer from apparently water rich rivers were once much talked about topics in the decades of 1960's and 1970's and later (14).

Another integrated scheme entitled the National Water Grid of India has also been conceived during the same periods and has not progressed much for various scientific and practical reasons (13, 7). We would, however, come back to the Brahmaputra-Ganga Link later since this is an important, if not the most, component envisaged in scheme of the River Link Project (or RLP).

3. THE PROJECT

The River Link Project (RLP) as postulated is based on two main considerations : Firstly, that surplus water is available in a number of river systems in the country. The Task Force, the Think Tank of the RLP have even identified them (Annexure I). Secondly, stress is on optimum use of water, river water in the present context, as envisaged in the National Water Policy (or NWP) (5a). The issue of surplus or excess water in a river basin or for that matter for any basin calls for well defined policy on allocation of water for different sectorial uses which subsequently form the basis of estimation of potential water requirements in quantitative terms. The important point is that the pattern of water use has to be compatible with potential water availability (both surface and underground), geo-physiographic features and bio-capabilities of the region, and obviously all these are required to be specified in unambiguous quantitative figures, not on speculative or incomplete and/or self-imposed data and information.

Spatial and temporal availability of water in a region may create both apparent surplus or scarcity of water. For instance, it would not be correct to consider the seasonal abundance (e.g. floods or water-logging or intense short spell precipitation, etc) as surplus or occasional shortage or drought as deficit. The issue of surplus or deficit of water has to be considered on holistic framework considering the long range trend of population rise, future development scenario, resource potential and geo-physical capabilities of a region or basin. Surplus of to-day may turn to deficit tomorrow due to ad-hoc or regular expansion of developmental programmes in agriculture, industries, etc, and/or other activities. Alternately, to identify a river basin as water surplus or deficit requires comprehensive field-based assessment on water availability in the different parts of the basin and also

along the course of the river during different seasons together with pattern of water use (prevailing and future) and the limits of the resource potential as stated above. It is not certain if any systematic investigation has ever been carried out in this direction to assess the status of water in any major river basin in the country leave aside the transboundary Himalayan rivers. The National Water Policy 2002 (or NWP) is unfortunately silent on the issues (5a). It is not out of context to recall two recent schemes envisaged pertaining to inter-basin transfer in the country of course in smaller scale. One of them contemplated during the 1990's or so to divert water from the west flowing Mahadayi, a small river outside the Krishna basin to the Malaprabha, a tributary of the east flowing Krishna to augment the flow of the Krishna, has to be abandoned due to non-existence of so-called surplus of water in the Mahadayi. Another project entitled the Sutlej-Yamuna Link Canal (the former is an important tributary of the Indus and also an international river itself and the latter is an important tributary of the Ganga) formulated in the early 1980's is

yet to be implemented for the donor, State of Punjab, has declined to honour the agreement on the plea that surplus water does not exist any more in that reaches of the Sutlej and any transfer of water from the Sutlej would go against the interests of the people there and may cause even social unrest. Would it be prudent to discount the issue? The matter is presently under the purview of the court of law. Judicial interventions are often useful to resolve conflicts and legal impasse. This however does not ensure any rational scheme of sharing of river water among the stakeholders. Populism or political leverage though is helpful at times to reach at some working arrangement cannot also be any basis of allotment or sharing of water. These arrangements usually change with change of political scenario - not an encouraging and practical way to achieve sustainable development.

4. THE LINKS

The Scheme of the river linking under the RLP has two distinct divisions:

- a) The Himalayan Links and
- b) The Peninsular Links.

It is planned to transfer the flood waters from the 14 Himalayan rivers considering them to be water surplus to augment the flow of the 17-Peninsular rivers besides supply of additional water to selected places in Andhra Pradesh, Tamil Nadu and Karnataka down south and western Gujarat with some share to the National capital and parts of Haryana, Rajasthan, Madhya Pradesh and Maharashtra (Annexure 1).

The Links are again grouped under five different components (Annexure 1). Functionally there are three distinct groups namely, some of the rivers or to be more specific some stretches of some of the rivers are meant to be the source of the so-called surplus water, some would carry or transfer (along with additional about 11,000 km of canal grids to be dug) the same to the target areas while the remaining rivers would be doing both. Of the five components, The Northern : 4 Rivers Link and The East: Linking the Brahmaputra with the Ganga are most important and vital meant to supply the bulk of the so-called surplus water schemed under the RLP. To be precise the scope and success, if any at all (?), of the RLP are largely hinged on these two Links.

The major share of the so-called surplus water would primarily be drawn from the three main river systems in the east and north- eastern regions of the country namely, the Ganga, Brahmaputra and Mahanadi in Orissa, totaling around 173 (bnm³) annually. An obvious question at this stage is the quantum of transfer planned in the first phase of the RLP would be the ultimate or would that change in future? For according to an earlier postulation by the National Commission for Integrated Water Resources Development Programme (or NCIWRDP), considered to be the brain- trust of the MOWR formed in 1996, a massive quantum of transfer around 302 (bnm³ annually) has been planned (7). This quantum would meet the future requirements of the selected drought-prone areas stated above and likely to be drawn naturally from the Ganga 117 units (1 unit = I(bnm³/Yr); or about 25.5% of the flow available at Farakka), Brahmaputra 174 units (or over 34% of the flow available at Dhubri) and 11 units from the Mahanadi in Orissa (or 16.5% of the annual flow) (?).

True that the east and north-eastern regions are endowed with more water than other parts of the country. For instance, the Ganga-Brahmaputra (or Ganga-Brahmaputra- Meghna) river systems (spread over five sovereign countries in Indian Sub-continent) cover roughly one-third of India's geographical area and possess nearly sixty percent of the country's surface flow of 1953 units. At the same time it is a historical fact that the Ganga basin in particular contains more people than any other regions in the country; the population density in the Ganga basin in India is over forty

percent in excess of the National average; to-day water stress conditions prevail in the Ganga basin (Table : 2). Further various reaches of the Ganga and Yamuna (the tributary of the Ganga) also suffer from “no-flow” to “functional no-flow” conditions (Annexure II) for different spells during the long dry months (18). Under the prevailing conditions transfer or diversion of any amount of water from the mid-reaches to the upper basins leave aside any transfer beyond the basin would amount to deprive, if not robbing, the basin and would obviously cause further stress. By the same logic transfer of substantial quantum of flow from the Mahanadi in Orissa would also be as good as an act of depriving the economically backward adjoining regions that suffer chronically from water scarcity; such act would further impede the programme of industrial expansion programme undertaken recently by the provincial government. It appears to be rather strange to consider the Mahanadi basin as water surplus area when the PCA of the region around the river in Orissa is about 1600 (CM/Yr) or less implying water stress condition (Table: I).

It may not be an overstatement that the scope and feasibility of the whole scheme of the RLP hangs around a single aspect namely, if a link canal to transfer water from the Brahmaputra (eg. Sankosh, Manas, Teesta) to the Ganga through the Indian territory, that is, through the ecologically sensitive and geo-physically fragile and unfavourable landform of the Terai (lying at the foothills of the Himalayan ranges in West Bengal) would be workable or not. It may be recalled that several schemes attempted in the recent past to transfer water from the Brahmaputra river systems to augment the dry weather flow of the Ganga upstream Farakka Barrage could not be executed out due to various valid reasons. For instance, the Brahmaputra-Ganga Link formulated unilaterally by India in the decades of 1970s to divert flow by gravity from the Brahmaputra at Jogigopa in Assam (India) and to carry the same through a dug out canal through Bangladesh to augment flow of the Ganga upstream Farakka Barrage could not materialize due to strong but valid objections from Bangladesh (15). The Jamuna-Padma or Ganga, which is known as Padma in Bangladesh, Link planned independently by Bangladesh in the 1990s could not be feasible mainly on eco-environmental grounds (1). During the same period but before the signing of the Treaty of Sharing of the Ganga Water at Farakka with Bangladesh (on Dec 13, 1996), WAPCOS (an Agency under the MOWR) had also worked out the Sankosh-Ganga Link through the Terai (in India) . The scheme could not get clearance from the Ministry of Environment & Forests, Government of India or MOEF on eco-environmental and other reasons. The construction of a link canal through the narrow stretches in the Terai would imply destruction of practically three internationally recognized reserve forests (eg. The Buxa Tiger Reserve, Jaldapara and Gorumara Wild Life Sanctuaries- all of them are habitats of some endangered and threatened species of flora and fauna), besides large scale encroachment on several prime ‘ tea estates’, agricultural lands, and displacement of large number of population (mainly poor and tribals) along the canal routes; over and above the drainage and eco-systems in the region would be completely disrupted by the link canal. Late Dr. K.L.Rao, a world renowned River and Hydraulic Engineer, believed to be the author of the Ganga- Cauvery Link and many other schemes and also the then Minister in the concerned Department in the Union Government could recognize all these implications and technicalities as early as the decades of the 1970s in the last century and eventually ruled out the possibility of any transfer of water from the apparently water abundant Brahmaputra system through Indian territory to the Ganga. He had stressed these points in his book published in 1975(15).

Now , it is somewhat strange, if not a mystery, that the Task Force of the MOWR have overlooked, if not totally ignored, the earlier observations and recommendations of the same Ministry and also the recent objections by the MOEF of the Union Government; and on the contrary formulated the scheme of a link canal (or MSTG) through the Terai ! An obvious question: is the environmental clearance superfluous and could be overlooked or bent or interpreted or even ignored to serve particular purpose ? Or the rule of law would vary from case to case ! Or these are unnecessary evils in the path of economic development that is unlikely to sustain !

5. CONCLUDING REMARKS

The scheme of the RLP, a super mega project without any parallel, has raised high hopes and expectations in various groups and corners and yet many issues and questions remain open and ambiguous and need clarification before one could consider them even conceptually (!). For example, the very issue that surplus water is available in a number of river systems in the country seems to be based on self-imposed data and dubious (?) hydrology contrary to field realities or/and scientific analysis. Simple statistics (Tables 1 &2) pertaining to the Ganga and Brahmaputra systems, the two main sources of surplus water, do not substantiate the claim and neither provide any convincing or encouraging arguments to justify inter-basin transfer. Fact remains that the mid- and lower reaches of the Ganga and some of its tributaries experience water stress conditions for some period almost regularly every year. It would be a grave mistake to consider flood waters as surplus and transfer the same in other basins would amount to depriving a river and its estuarine reaches from the much-needed life-providing boosts. Transfer of the seasonal excess water from the mid-reaches of the Brahmaputra through the Indian Territory (i.e. the so-called Siliguri chicken neck) is also not feasible from various considerations.

Secondly the methodology of the selection of the target areas and basis of allocation of the supply (i.e. quantum) are also shrouded with ambiguity . For instance, allocation of further supply of additional water to western Gujarat and also Rajasthan appear to be puzzling and raises obvious question in view of the fact that reasonable provision of additional supply has already been incorporated for the said regions under the Narmada Project by raising the height of the dam of the Sardar Saravar Project against various oppositions and protests on the plea that creation of additional storage would ensure supply of water to those regions. Let us take the case of Rajasthan, which has already been receiving water through the Rajasthan Canal. However, to augment the supply some additional flow would be made available under the SSP when completed. Provision of further supply of additional water under the RLP seems to be strange !

Doubts are prevalent among experts if large scale transformation of the basic physical characters of many of the semi-arid and parched areas to be irrigated under the RLP beyond the limits of the resource potential and bio-productive capabilities and that too on borrowed and scarce resource like water would be viable economically and sustainable physically. Blooming the desert no longer generates any sensation or enthusiasm among general public leave aside experts and farmers. Farmers in general have more faith on local resources than those to be brought from far away places. For they have relatively better knowledge and control on the local resources.

Massive assaults to be caused by the RLP, if implemented, on the physical, landscapes, drainages, human settlements, crop lands and forests, wild life habitats, eco-environment, etc. would result in the dislocation and disruption and irreparable damages of many of the established set-ups and systems on physical, environmental, socio- cultural and economic fronts in particular. Some idea of the physical assault of the Ken-Betwa Link, a tiny scheme under the RLP could be found in Table 3. Disturbance and disruption of the established drainages in wider scale would likely change the physical map of the country or for that matter of the Sub-continent. The proponents of the RLP have paid little attention on the far reaching consequences in the above changes and also on considering the various indirect and hidden costs which cannot be neglected or wished away in estimating the real cost of the project and the cost of its operation. Resettlement and rehabilitation of the large number of population (e.g. nearly three million as per conservative official figures), mainly poor belonging to various tribal and ethnic communities are themselves Herculean job in the form of physical work, time, money, etc. Besides locating and acquiring of proper sites, which in most cases are poor substitute of the lands lost in terms of productivity, environmental quality, water availability and the basic infrastructures (viz. roads and transports, health, education etc.) and above all potential providers of livelihood per unit area of the land acquired are also a huge job .

Seed of discontent in the social front is practically inseparable from river valley projects since equitable distributions of the share of the benefits generated by the project among the stakeholders could hardly be achieved or done rationally. Traditionally the people ousted by the project are the worst sufferers; they often make the greatest sacrifice (seldom voluntarily) for the project by parting away with their ancestral homes, crop lands, livelihoods, skills and trades including traditions and cultures. In most of the cases they are not properly rehabilitated, nor do they receive or get proper share of the benefits generated by the projects. They are not only the deprived lots but are also the forgotten lots ! It may not be out of context to mention that lack of proper rehabilitation of nearly two lakhs of poor people ousted by the ongoing Sardar Sarovar Project (a major component of the Narmada River Valley Project —a pigmy in comparison to the RLP) have generated various protests, counter-protests, etc. is yet to be settled. The immediate impacts of the RLP, if implemented, in the social front would be discontent, jealousy and rift among those who receive directly and/or indirectly some share of the benefit and those who receive a little or none. Social disparities in the long run would lead to social tensions and conflicts and obviously detrimental to growth and sustainability not to speak of National integrity and development.

Any discussions on the RLP would not be complete without some reference to the estimated cost and time frame to implement the scheme. To this end the conditions prevailing in the country portray a dismal picture. Today the period of completion of a conventional water project in general has gone up by an additional decade, if not two, than the planned schedule. The case on the cost factor is still more worse. The overall costs have escalated by at least ten fold, if not more, than the estimated fund. It would be anybody's guess how many more decades the Nation would have to wait and how many more times the estimated costs would the RLP require, if accepted for implementation. Source of fund is another problematic issue and has been left out of the purview of the present study. On the matter of operation and maintenance the conditions are far from

satisfactory and most, if not all, of the water projects in the country are running far below the designed level. The management of the RLP would remain an open issue for nobody has any knowledge of a super mega project like the RLP leave aside anything about experience of operation and maintenance.

Strong reservations persist in various corners if the made- to-order (?) RLP (if it be permitted to put it that way (!)) considered in the official circles and various socio-political and interest groups as all cure of the chronic ills and adversaries in the water sector at all achieve that when in real life chaotic and anarchic conditions prevail water sector today in the country (13b). Now, simple calculations show that per capita availability of freshwater (or PCA) (presuming equitable distribution among the population) in the country is rapidly declining (Fig.1). The trend would continue in the coming years as we are yet to achieve population stabilization. The gloomy statistics (based on a recent UN study as illustrated in Fig.1) reveal that we would be facing severe water crisis around 2050, if not early. It has been observed that the conditions could be improved if we could set for ourselves a reasonable but firm growth rate to contain the population rise. Such action would also make way to achieve improvement in other vital sectors as well. It is obvious that population control is also a way to confront water crisis.

Traditionally the MOWR is known not to entertain delusion or error. As for example in about a decade and a half they could not come clean with the necessary facts and figures about the real costs and actual benefits of the Narmada River Valley Project. and whatever available are again questionable. Doubts also persist if the real costs and motive(s) behind the RLP scheme would ever be revealed. It is interesting to note that contrary to traditions the MOWR have been considering seriously to rename the project by Inter-Basin Transfer replacing the River Linking Project hoping that the renaming of the project would clear and remove various doubts and confusions and criticisms including transboundary implications. The Inter-Basin Transfer, it may

be recalled, the theme topic of the 1996 Water Resources Day observed in the country, could make little impact in the concerned circles and departments.

It has to be recognized that there is a stake for any benefit grabbed from Nature for Nature is not a perpetual provider of free lunch. Numerous cases exist where scheme of transformation of arid and semi-arid tracts as mentioned above though achieved encouraging results and yielded profitable benefits in the early years of the project have found to cause various untoward effects and constraints on the physical, social, environmental and also on economic fronts in the long run. In the Man-Nature struggle there is no such things as win-lose or lose-win situation or condition ; only win-win or lose- lose condition seems to be the feasible and practicable. Win-Win condition implies desirable or acceptable being sustainable and the lose- lose condition is unsustainable and therefore undesirable.

Lastly, we are confronted with a big question, would the proponents of the RLP stick to their gun and go ahead with the scheme which looks like gains and benefits for the selected target in a limited way and that too for short span of time in lieu of great risks and uncertainties. Or would they ponder over the rational views and suggestions and consider things on holistic perspectives and avoid what look like incalculable damage, if not disaster in a catastrophic scale, Would it be pragmatic and wise to ignore the lessons of the Aral!

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TABLE NO. 1 Water Use Index (Based on U.N. Recommendation)

STATUS	PER CAPITA	WATER REQUIREMENT	Number of persons served per (MCM/Yr) of River Flow.
	CM/Yr	lpd	
Water stress	1700	4658	600
Water scarcity	1000	2740	1000

Absolute water scarcity	500	1370	2000
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N B: Internationally 1000(CM/Yr) is widely accepted as the minimum quantum of water required by a person to meet personal requirements and his /her share of water for production of food, energy, other requirements and preservation of the eco-environment in developing countries like ours

Table No 2 : Water Potential Status of The Ganga & Brahmaputra River Basin

River System	Basin Area (Mha)		Population (million) projected 2004		Annual Flow (MCM)	WPI (MCM) km ²	Per capita Availability		Number of People Served per unit (MCM /Yr) of flow
	Indian	Basin	Indian	Basin			CM/Yr	lpd	
Ganga	86.2	111.7	410	445.41	567201	0.51	1273	3488	785
Brahmaputra - Meehna system	27.37	101.31	52.9	199.59	605098	0.605	3031	8306	331(a)
Ganga Brahmaputra - Meghna system	113.57	213.01	462.9	645	1172299	0.55	1818	1818	550

N B: (a) For Brahmaputra only: WPI=0.603; (Water Potential Index) =Annual Flow (MCM)/ Basin Area (km²)

TABLE 3; PARTICULARS OF THE KEN-BETWA LINK : A component of RLP. (Based on the information available in ref. 19)

Scheme: To transfer surplus water(?) from the Ken (360 km), annual flow 11.3(bnm³) to the Betwa (590 km): annual flow 10(bnm³: catchment of both the rivers in MP &UP: both right hand tributaries of the Yamuna of the Ganga system, the main stream); one high dam Daudhan Dam (287 /m) on the Ken: 251 (km) link canal plus the Sharda- Sahayak Canal through the Jim Corbet National Park (elephant reserve area) in UP.

Direct damage and loss: submergence-2171(ha) agri-land 8579(ha) other lands, 19 villages with 900 families(about 50%ST&SC) to be ousted; 50 (km²) of Panna National Forest, that is, substantial loss of forest wealth (teak, sal etc): distruption of habitat of some endangered wild life (eg. leopard, tiger, birds, etc and also elephant in the Jim Corbet National Park);

Transfer rate factor (or TRF = quantum of annual transfer) (km³/yr) x distance of transfer (km) - around 1000 (about the size of an average project in the scheme of inter-basin water transfer plan).

ANNEXURE -1 OUT LINE OF THE PROJECT

Scheme: Linking 36 rivers and Rajasthan Canal: Construction of 27 additional dams and 11,000 km canal grid.

ESTIMATED COSTS: Rs. 560,000 crores (alternately Rs. 700,000crores according to the Chairman, Task Force, MOWR, Gol)

PROPOSED HIMALAYAN LINK

- | | | |
|-----------------------------------|-----------------------------|---|
| 1. Kosi-Mechi | 2. Kosi-Ghagra | 3. Gandak-Ganga |
| 4. Ghagra-Yamuna | 5. Sarda-Yamuna | 6. Yamuna-Rajasthan Canal |
| 7. Rajasthan Canal-Sabarmati | 8.Chunar-Sone Barrage | 9. Sone Dam - Southern Tributaries of Ganga |
| 10. Brahmaputra-Ganga (MSTG) | 11. Brahmaputra (JTF) (ALT) | 12. Farakka-Sundarbans |
| 13. Ganga- Damodar - Subarnarekha | | 14. Subarnarekha-ahanad. |

PROPOSED PENINSULAR LINKS:

1. Mahanadi (Manibhadra-Dowaswaram)
2. Godavari(Inchampalli) - Krishna (Nagarjunsagar)
3. Godavari (Inchampalli Low Dam) - Krishna (Nagarjunsagar Tail Point)
4. Godavari (Polavaram) - Krishna Viyaywada)
5. Krishna (Allamatti) - Pennar
6. Krishna (Srisailam) - Pennar
7. Krishna (Nagarjunsagar) - Pennar (Somasilam)
8. Pennar (Somasilam) - Cauvery (Grand Anicut)
9. Cauvery (Kaitalai) - Vaigal - Gundar
10. Ken-Betwa
11. Parbati - Kalisindh - Chambal
12. Par--Tapi -- Narmada
13. Damanganga - Pinjal
14. Bedii - Varda
15. Netravati - Hemavati
16. Pamba - Achankovil - Vaippar.

A. Southern : 16 Rivers Link - Son, Samodar, Subarnarekha, Mahanadi - meant as transfer link to divert water to Andhra, Tamilnadu and Karnataka.

B. Northern: 4 River Link - Kosi, Gandak, Ghagra, Ganga, Mechi & Yamuna - meant to convey water to Haryana and Delhi.

C. West: 7 Rivers Link - To convey water to Gujarat through Rajasthan : Part of MP and Maharastra would get some share of water.

D. East: Linking the Brahmaputra with the Ganga to feed Farakka to augment flow at the Sundarbans and to ensure committed flow through the Padma.

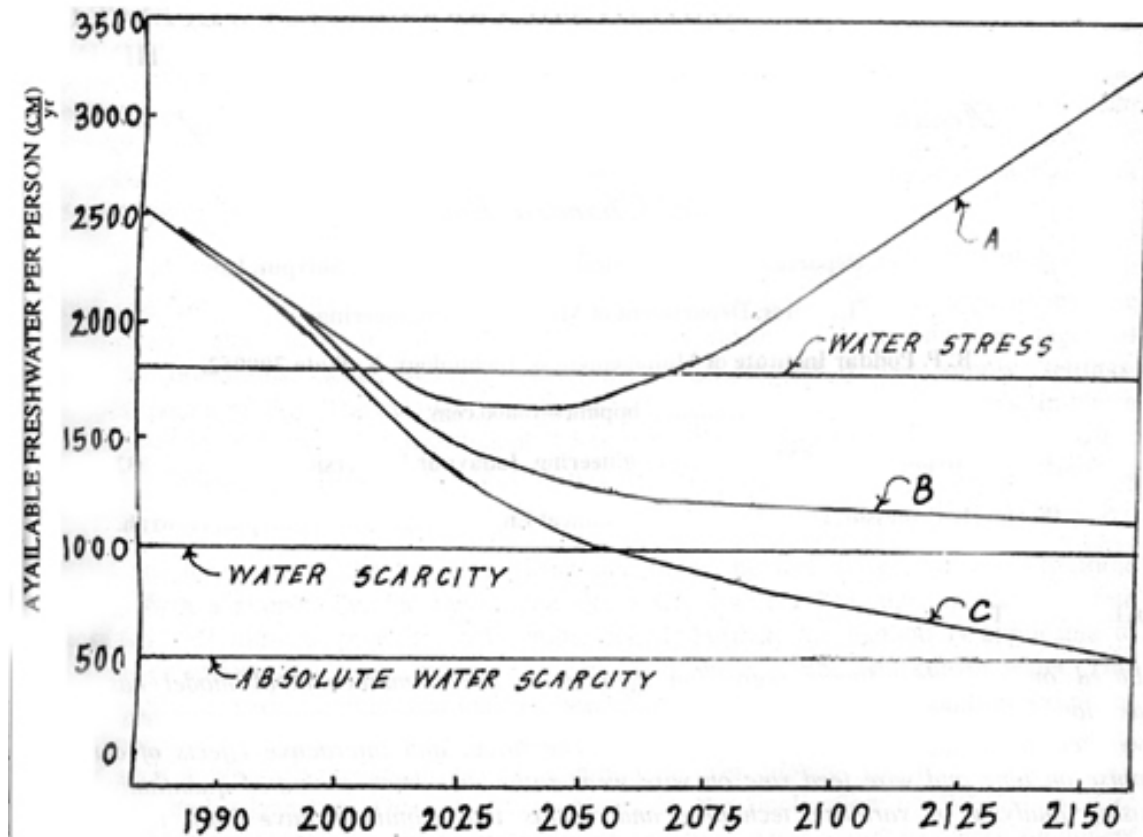
E. Four More Link: Ken, Betwa, Parbati, Kalisindh, Chambal, Par, Tapi, Narmada, Damanganga, Pinjal.

ANNEXURE - II

A river has multiple functions of which some are considered to be the basic namely , flood release (i.e. drainage) , transport of silts and sediments , maintenance of quality of river water and maintenance of riverine and estuarine eco-systems . To perform each function some threshold or minimum flow through the river would be needed. “No-flow “ situation implies absence of any

discharge or flow through some stretches of a stream or all along the stream or river". "Functional no-flow" refers to the flow below or lower than the threshold

ANNEXURE - III



BASED ON UNPOPULATION PROJECTION : RATE OF GROWTH IN THE FERTILE GROUP

A :	1.56	CHILDREN	PER	WOMAN	(LOW)
B :	2.07	"	"	"	(MEDIUM)
C :	2.58	"	"	"	(HIGH)

GOI : TARGETED TOTAL FERTILITY RATE (OR TFR) SET AT 2.1 CHILDREN PER WOMAN IN THE FERTILE AGE GROUP UNDER POPULATION POLICY, DECEMBER 1997 TILL 2010

FIG.-I. INDIAN SCENARIO : PER CAPITA AVAILABILITY OF FRESHWATER.

STATISTICAL ANALYSIS TO STUDY THE PARAMETRIC INFLUENCE ON WIRE WEAR RATIO IN WIRE ELECTRICAL DISCHARGE MACHINING

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ABSTRACT

Based on multiple linear regression method, linear mathematical model has been developed to correlate the wire wear ratio and selected process control parameters in the wire electrical discharge machining process. The direct and interactive effects of current, pulse on time and wire feed rate on wire wear ratio have been evaluated quantitatively by using analysis of variance technique and results thus obtained have been represented graphically.

Key words: multiple linear regression, analysis of variance

1. INTRODUCTION

Wire electrical discharge machining (WEDM) is a spark erosion process used to produce complex two and three-dimensional shapes through electrically conductive work pieces. WEDM differs from conventional electric discharge machining (EDM) in that a thin (0.05-0.3 mm diameter) wire performs as the electrode. The wire which unwinds from a spool, feeds through the work piece. A power supply delivers high frequency pulses of electricity to the wire and the work piece. The gap between the wire and work piece is flooded with localized stream of deionized water, which acts as the dielectric. Work piece material is eroded ahead of the traveling wire by spark discharge, which is identical with those in conventional EDM.

When each pulse of electricity is delivered from the power supply, the insulating properties of the dielectric fluid are momentarily broken down. This allows a small spark to jump the shortest distance between the wire and work piece. A small pool of molten metal is formed on the work piece and the wire at the point of spark. A gas bubble forms around the spark and the molten pools. As the pulse of electricity ceases and the spark disappears, the gas bubble collapses. The on-rush of cool dielectric causes the molten metal to be ejected from the work piece and the wire leaving small craters. This action is repeated hundreds of thousands of times each second during the WEDM processing. This removes material from the work piece in the shape opposite that of the wire.

Optimum utilization of the capability of the WEDM process requires the selection of an appropriate set of machining parameters. The machinability database supplied by the

manufacturer helps the user and the system to make decision regarding the stages of machining operations, wire electrode materials, machine and power supply settings, electrode position, etc. The available technology data based on manufacturer's in-house experimentation is helpful but insufficient. Moreover, the manufacturer's guidelines for the selection of machining parameters are conservative in nature and do not lead to optimal and economically effective use of the machines.

WEDM has been one of the fastest growing manufacturing technologies of the last three decades. With a simple, i.e. the wire electrode, a CNC wire EDM machine can generate almost any 3-D intricate parts at considerable speed. Further, the method is applicable to an extensive variety of work materials including hard alloys, CBN, and silicon wafer. This is apparently a very flexible and agile material removal process. In addition, a major breakthrough in cutting speed has been achieved since the 1980s. Now, most manufacturer claims such a high cutting speed as 300 mm/min or even higher. The technology is still developing and advancing. One of the problems in the application of WEDM is wire rupture, which terminates the cut in an awkward situation. After a rupture, work alignment has to be recovered and the broken wire has to be replaced. Manual wire feeding turns out to be a difficult operation. Sometimes permanent damage is left on the surface of the work.

The demand for very high cutting speed and cutting without attendance require the total elimination of wire rupture, when high cutting load is applied. Various automatic wire feed mechanisms are available on some sophisticated machines. They allow an automatic restart of the terminated process, but it does not repair the surface damage. With the same parameter setting the process tends to experience another rupture after the restart. Thus an "intelligent" system is usually called up to change the parameter setting after every wire rupture. Such a system is based on off-line knowledge about wire rupture. Unfortunately, the mechanisms are still not understood completely.

Scott, Boyina, and Rajurkar, [1] presented a formulation and solution of multi-objective optimization problem for the selection of the best control setting on a wire EDM. The metal

removal rate and surface finish were taken as the measures of performance for the proposed model. It was concluded that fundamental limits on machining accuracy depend on the dimensional consistency of wire and positional accuracy of the table. Lian, Chu, and Yan, [3] observed that wire rupture in the WEDM process is a serious problem to manufacturers. A new computer aided pulse discrimination system based on the characteristics of voltage waveform during machining was developed and discussed the same in their paper. Luo, [4] observed that in the application of wire EDM, wire rupture is very troublesome and impedes further increase of cutting speed. Guo, Wang, Huang, Yue [5] discussed that particle-reinforced material is difficult to machine. In general, the conventional methods to shape such materials produce worse surface quality and serious wear of the cutting tool and thus inefficient. The authors studied machinability adopting orthogonal design and observed that the electrical discharge energy was closely related to machining stability. A good machining effect could be attained when the electrical parameters were properly selected, otherwise, the machining might be unstable resulting in wire breakage. Hewidy, Taweel and Safty [6] observed that the WEDM could be used successfully for machining parts made of many new materials particularly those used in the aerospace and medical industries. Using WEDM technology, complicated cuts can be made through difficult to machine electrically conductive components. The high degree of accuracy and the fine surface quality made WEDM valuable.

The main purpose of the present study is to investigate the effects of machining parameters on the wire wear ratio (weight loss of wire after machining divided by the initial wire weight) and apply statistical techniques to obtain the level of significance of machining parameters on the WWR. The study has also been aimed to determine relationship between the WWR and some selected

machining parameters. The variation of the WWR has been investigated under different machining parameters, namely, pulse on time, peak current and wire speed. The experimental results have been modeled statistically in terms of the machining parameters using multiple regression method. The effects of the machining parameters on the WWR has been evaluated statistically and the level of significance of the parameters affecting the WWR has been determined quantitatively by using analysis of variance method (ANOVA). Less effective parameters (or combination of parameters) on the WWR have been removed from the statistical model and a mathematical relationship, which could be successfully implemented to the real machining tests, between the WWR and the machining parameters, has been proposed.

2. EXPERIMENTATION AND DATA COLLECTION

In this study, the effects of parameters on wire electrode wear have been investigated experimentally in WEDM. The experiments have been conducted under different settings of pulse on time, peak current and wire feed rate. Brass wire of 0.25 mm diameter and AISI4140 steel plate of 15 mm thickness have been used as tool and work piece material respectively. It is found experimentally that the pulse on time and peak current are directly proportional to the WWR and the wire feed rate is inversely proportional to the WWR. The

experimentation has been performed on a EURO-CUT-MARK-1-734 WEDM machine (Make: ELECTRONICA MACHINE TOOLS LTD, Pune). For the determination of WWR (wire wear ratio) initial wire weight and wire weight loss have been determined. The WWR has been calculated from the following equations:

$$\text{WWR} = \text{WWL} / \text{IWW},$$

where WWL = Wire weight loss, and IWW = Initial Wire weight

$$\text{WWL} = \text{IWW} - \text{FWW},$$

where, FWW = Final Wire Weight.

The statistical model of the WWR is expressed as

$$\text{WWR} = a_0 (\text{Ton})^{a_1} (\text{Ip})^{a_2} (\text{WF})^{a_3}$$

Here a_0 , a_1 , a_2 , constants of the power function, are determined using nonlinear regression analysis method. From there results (Table 1) the wire wear ratio, ie, WWR can be related with the common conventional parameters as

$$\text{WWR} = 0.00075(\text{Ton})^{1.1432} (\text{Ip})^{0.615} (\text{WF})^{0.3031},$$

in which, Ton—Pulse on time (μs),

IP—Peak current (amp.)

and WF—Feed rate (m/min).

From the above empirical model it is clear that WWR is directly proportional to the pulse on time and peak current and inversely proportional to wire feed rate.

3. REGRESSION MODELLING AND ANOVA

Regression analysis can be used to model the relationship between a response variable and one or more predictors. The code MINITAB provides various least-squares and logistic regression procedures. The regression equation is an algebraic representation of the regression line and is used to describe the relationship between the response and predictor variables. The regression equation takes the form of:

$$\text{Response} = \text{Constant} + \text{Coefficient (Predictor)} + \dots + \text{Coefficient (Predictor)}.$$

$$\text{or, } Y = b_0 + b_1X_1 + b_2X_2 + \dots + b_kX_k,$$

where,

Response (Y) is the value of the response, and

Constant (b_0) is the value of the response variable when the predictor variable(s) is zero. The constant is also called the intercept because it determines where the regression line intercepts (meets) the y axis,

Predictors (x) is the value of the predictor variable(s)

Coefficients (b_1, b_2, \dots, b_k) represent the estimated change in mean response for each unit change in the predictor value. In other words it is the change in Y that occurs when x increases by one unit.

The coefficient table (ANOVA) lists the estimated coefficients for the predictors. (detailed in Table 2) Linear regression examines the relationship between a response and predictors. In order to determine whether or not the observed relationship between the response and predictors is statistically significant, it is necessary to identify the coefficient p-value (called probability of significance). The coefficient value for p (p-value) tells whether or not the association between the response and predictors is statistically significant. Comparison should be made between the coefficient p-value to the selected α -level (confidence level). If the p-value is smaller than the α -level, it can be concluded that the association is statistically significant. A commonly used α -level is 0.05 for 95% confidence level.

Table 1: Experimental data

Serial no	Ton (μ second)	Ip (amp)	WF (m/min)	WWR
1	10	13	4	0.02778
2	10	13	6	0.02769
3	10	13	8	0.02755
4	10	18	4	0.05243
5	10	18	6	0.04871
6	10	18	8	0.03933
7	10	23	4	0.05992
8	10	23	6	0.04985
9	10	23	8	0.04273
10	15	13	4	0.05046
11	15	13	6	0.04341
12	15	13	8	0.03891
13	15	18	4	0.06085
14	15	18	6	0.05208
15	15	18	8	0.04648

16	15	23	4	0.08843
17	15	23	6	0.07808
18	15	23	8	0.07148
19	20	13	4	0.10527
20	20	13	6	0.10142
21	20	13	8	0.08571
22	20	18	4	0.12091
23	20	18	6	0.11111
24	20	18	8	0.08605
25	20	23	4	0.13140
26	20	23	6	0.12349
27	20	23	8	0.10054
28	25	13	4	0.12931
29	25	13	6	0.11667
30	25	13	8	0.10860
31	25	18	4	0.15102
32	25	18	6	0.13529
33	25	18	8	0.12524
34	25	23	4	0.15336
35	25	23	6	0.13481
36	25	23	8	0.12297
37	30	13	4	0.12711
38	30	13	6	0.11519
39	30	13	8	0.11263
40	30	18	4	0.14248
41	30	18	6	0.12000
42	30	18	8	0.11877
43	30	23	4	0.18392
44	30	23	6	0.17010
45	30	23	8	0.15388

The **ANOVA** is a technique based on statistical method for data analysis which is used to infer some important conclusions about the level of significance of the effect of process parameters on the selected response. The ANOVA technique calculates Fisher's F value of a term or factor (main effect or interactive effect) on the selected response. 'F' is termed as variance ratio. Based on calculated F ratio, this technique compares calculated F value with that of tabulated F value. If calculated F value appears greater than tabulated F value it can be concluded that the direct/interactive effect of factor/combination of factors on the selected response is significant, for a particular confidence level, depending on the investigator. MINITAB uses 'p' value rather than comparing F calculated with that of F

tabulated. P is termed as probability of significance. If P value for a term appears smaller than 0.05 (for 95% confidence level) it can be concluded that the term imposes significant effect on the response. MINITAB's ANOVA procedures, however allow models with both qualitative and quantitative variables. MINITAB's ANOVA capabilities include procedures for fitting ANOVA models to data collected from a number of different designs with multiple response, for fitting analysis of means models and graphs for example main effects and interactions effect plots. ANOVA table for wire wear ratio is shown in Table 2. The significant factors/combination of factors which impose remarkable effect on the WWR have also been indicated. The developed mathematical model along with relevant model statistics are also included (Table 3.1-3.2).

Figures 1 to 4 represents main effect, interactive effect and response surface plots showing the influence of the process parameters on wire wear ratio in WEDM.

Table 2: ANOVA for WWR

Source	DF	SS	MS	F	P
Ton	4	0.0669368	0.0167342	2825	0.000
Ton	4	0.0669368	0.0167342	2825.33	0.000
IP	2	0.0067093	0.0033547	566.39	0.000
WF	2	0.0030771	0.0015386	259.76	0.000
Ton*Ip	8	0.0020497	0.0002562	43.2 6	0.000
Ton*WF	8	0.0005219	0.0000652	11 .01	0.000
Ip*WF	4	0.0001932	0.0000483	8.15	0.001
Error	16	0.0000948	0.0000059		
Total	44	0.0795827			

*Significant at 95% confidence level

The regression equation is

$$WWR = -0.0338 + 0.00530 \text{ Ton} + 0.00298 \text{ Ip} - 0.00506 \text{ WF.}$$

Table 3.1: Model statistics for WWR

Predictor	Coef	SE Coef	T	F
Constant	-0.03381	0.01237	-2.73	0.009
Ton	0.0052962	0.0002701	19.61	0.000
IP	0.0029817	0.0004678	6.37	0.000
WF	-0.005063	0.001169	-4.33	0.000
S = 0.01281		R-Sq = 91.5%		R-Sq(adj) = 90.9%

Table 3.2: Analysis of Variance

Predictor	DF	SS	MS	F	P
Source	3	0.072855	.024285	147.99	0.000
Regression	41	0.006728	0.000164		
Total	44	0.079583			

4. DISCUSSIONS AND CONCLUSION

The ANOVA for (WWR) have been calculated in Table 2. In the ANOVA table degree of freedom (DF) represents the number of independent observations that can be performed to check the level of significance of the effect of factor or factors on the response. In ANOVA table the following notations are used:

DF=Degree of freedom, SS= Some of squares of deviations, MS=Mean square=SS/DF,

F=Fisher's F ratio=sum of squares for a term/sum of square for the error term,

P=Probability of significance.

It has been observed that the P value for the main effect & interactive effect of selected factor combinations are less than 0.05. So it can be concluded that the direct effect of (Ton), (Ip) and (WF) and their possible two-way interactive effect all are highly significant on **WWR** at 95% confidence level.

Figures 1 and 2 indicate that the direct effect of pulse on time and peak current becomes positive. That is increase in Ton or Ip results increases in WWR, however the rate of increase of **WWR** with respect to Ton and Ip are different.

Figure 3 represents the negative effect of WF on **WWR**. It has been observed that while increasing WF (keeping other parameters constant) **WWR** tends to decrease.

Tables 3.1 and 3.2 represent model statistics along with the ANOVA. The corresponding regression equation that represents mathematical relationship of (Ton), (Ip) and (WF) to predict WWR has also been shown. It is observed that, in relation to the regression model, the constant as well as all the coefficients of all the predictors have been found significant at 95% confidence level. So it can definitely be concluded that the derived regression equation is efficient enough to predict (WWR) for different factor combinations, of course within experimental domain.

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INDUSTRIAL LIGHTING

S K Alley

INTRODUCTION

While performing his daily works a normal person places more reliance on his sight than any other senses. He obtains most of his information about the outside world by means of his sight. The eye can portray to the brain such impression as are carried to it by light waves and if these light waves are not rational then its effect on a normal person is similar to that of partial blindness. The best of visual information in an industry can be obtained by adequate and uniform illumination of the workplace. The number of accidents in industries attributable to inadequate or insufficient illumination is fairly high. A good illumination, that provides a surface luminance (brightness) that is both adequate and uniform, has therefore been recognized as a very important factor of preventing industrial accidents. The importance of good illumination has, so far, not been recognized by the plant's top management to its fullest extent in our Industries and the violations endanger the workers regardless of the physiological condition of their vision. A good number of industrial workers are often found to be the victims of 'double handicap of poor lighting and defective eyesight'.

“One of the most common safety violations in Industries is insufficiency of illumination.”

Principles of good lighting: Good lighting is necessary in all buildings, including industrial buildings, passage ways, corridors, stairways, and control rooms etc. for the following three aims:

1. To promote the works carried on inside the building;
2. To encourage safety of people engaged in the building;
3. To create, in conjunction with the structure and decoration, a pleasing environment conducive to interest and a sense of well-being.

Fulfillment of above aims requires:

1. Careful planning of brightness and colour patterns within the working area and in the surroundings so that attention of workers is naturally drawn towards the important areas e.g. fire points, safety slogans, safety and environmental pollution control policies, electric room, notice board etc. and that writings and symbols are seen quickly and accurately, and that there is no sense of gloom and monotony inside work environment; and

2. Use of directional lighting where appropriate to assist the workers to perceive their task detail.

An improper illumination can cause discomfort to workers, accidents, defective production and defects in the eyesight. To achieve the aims of good illumination the following are needed to be considered:

- Control of direct or reflected Glare from light sources to eliminate visual discomfort.
- Maintenance of adequate illumination level appropriate to the accompany and the visual tasks to be performed.
- Installation of artificial lighting to supplement natural lighting, if required.
- Provision of special lighting to assist in typical visual tasks like polishing and buffing, whenever required. .

- Proper maintenance of lighting installations including that of rooftop glazing on regular and routine basis.
- Maintenance of illumination level, at all times, that workers find it easy and comfortable to move and work and that on sudden changes in illumination level takes place.
- Judiciously planned luminance level (brightness) and color of the walls, ceiling and floor to provide adequate illumination to workplace. Reflection factor in case of walls and ceiling could be as low as 0.1 for dark colors and as high as 0.7 for white colors.

ADVANTAGES OF GOOD LIGHTING :

“Lighting is the illumination of the surface of objects in order to make the objects visible or discernible to light-sensible substance or devices”

The following are the advantages of good lighting:

- Good illumination generally improves the working conditions and raises the productivity of labor.
- Good illumination is beneficial to a worker’s general physiology and induces a psychological state that is favorable to him for his work or relaxation.
- To the extent accidents result from fatigue, good lighting is a preventive measure.
- Proper and adequate illumination installed to suit the type of work to be done, result is maximum of production and minimum of inefficiency.
- Good illumination indirectly helps to reduce the number of accidents.

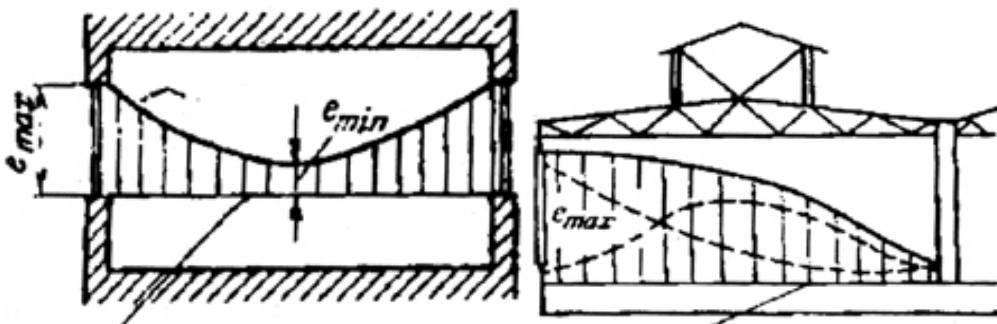
KINDS OF ILLUMINATION:

Illumination can be natural, artificial, or mixed,

Natural light –It is created by natural light sources, such as the sun or the moon. They vary considerably depending on such factors as time of day and year, the geographic latitude of the locality, and atmospheric conditions. Natural lights produce the following luminance on open horizontal surface:

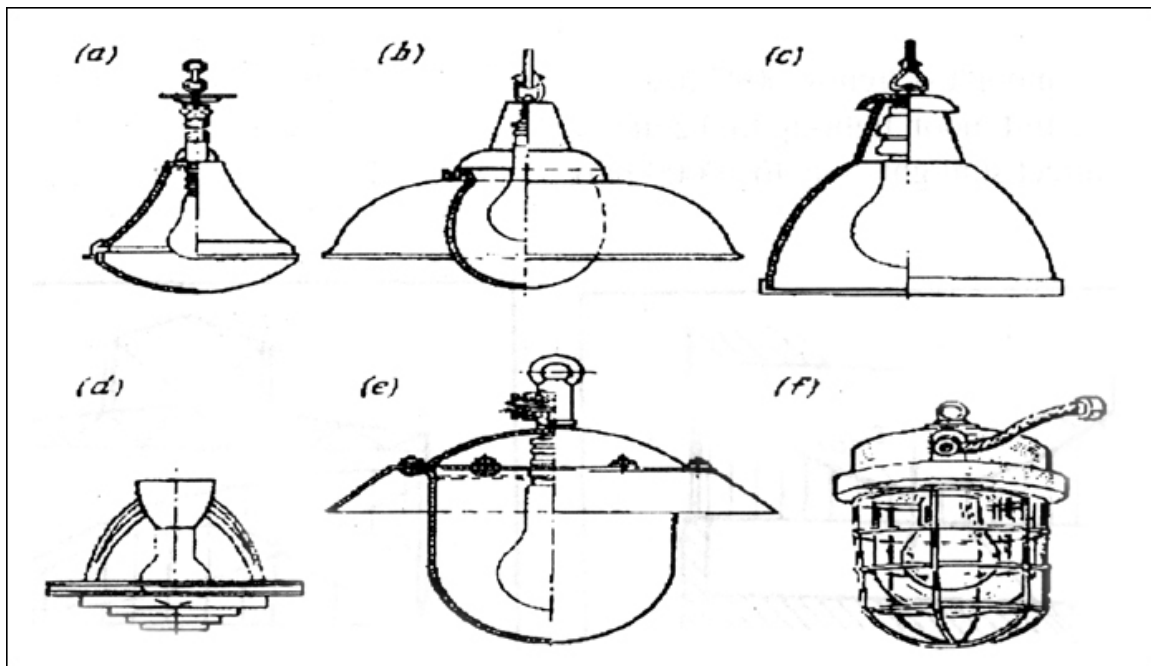
erable depending on such factors as time of day and year, the geographic latitude of the locality, and atmospheric conditions. Natural lights produce the following luminance on open horizontal surface:

- For a moonless light-0.0005 lux
- For a full moon light-up to 0.2 lux
- In direct sunlight —up to 100000 lux.



Natural light in an industrial building can be lateral, from skylight, and mixed, and is provided through side windows, sky lights (windows in a roof), or both. Natural illumination within buildings can be improved by its correct orientation and by applying light colored finishing of rooms. In the case of non-square buildings, if the length is east-west, its orientation is north-south.

Artificial light-Although from the physiological point of view natural illumination is the most favorable kind of illumination for human being, it is some times insufficient and is to be made up by artificial lighting. In many cases, engineering or economical consideration justify construction of without any natural illumination. Rooms which require constant temperature & humidity and also require the best cleanliness & rigid illumination levels are to be provided with artificial lighting. Since the turn of 20th century the artificial illumination became widespread and is now being regulated by basic quantitative and qualitative standards. The West Bengal Factories Rules, 1958 prescribes the quantitative and qualitative standards of illumination in Rules 31 and 32. Indian Standard on Code of Practice for Interior Illumination [IS 36(part II)] -1966 prescribes the values of illumination for Industrial Building and Process.



Basic types of lighting fixtures

(a) and (d) diffuse light; (b) and (c) direct light; (e) dust and water proof fitting; (f) explosion-proof fitting

Incandescent lamps and gas discharge devices are commonly used as sources for artificial illumination. The basic standard characteristics of the electric lamp are the rated voltage, wattage, luminous efficiency and service life. Gas-discharge devices provide illumination of much better quality as the spectrum of their luminous radiation is much closer to that of daylight. They can be source of accident causation only when they are badly designed, badly installed, or poorly maintained, and also when prescribed standards are violated e.g.

1. *Flickering tubes:* This is caused by defective condition of tubes or tube, which has reached its life-limit. This creates eye strain and fatigue.

2. *Stroboscopic effect:* Gas-discharge devices can produce a stroboscopic effect are badly designed, badly installed, or poorly maintained, and also when prescribed on visual sensation. Rapidly moving or rotating objects may seem to be immobile because of this effect. The phenomenon occurs due to rapid light pulsations that are generated by an alternating current. The stroboscopic effect is undesirable in Industries because it may prove to be the cause of accidents. This can be avoided by using 'Two-Lamp ballasts switching circuits' specially designed to provide power factor correction and to minimize the stroboscopic effect.
3. *Misadjusted reflectors:* This creates a source of glare.
4. *Installation within the line of vision:* Absence of proper louvers or of control of brightness intensity causes eye-strain or glare.
5. *Poor maintenance:* This reduces the lighting far below the level for which it was designed. Usually low or reduced level of lighting because of poor maintenance means too light for safe and efficient work.
6. *Lack of uniformity:* wide variation in intensity of light in adjacent areas is a source of accident because the eyes can not accommodate quickly enough the condition-particularly when workers such as crane operator or truck driver move from one lighting condition to another.
7. *Shadows:* Shadows or spotty illumination are not conducive to either production or safety.
8. *Inadequate amount of lighting:* Low level of lighting becomes an accident cause by resulting eye-strain or fatigue. It may also be a major cause for workers to fail to wear protective glasses.

LIGHTING AND SAFETY

For safety of the workers in their physical environment, lighting is important and provides normal working condition that suits best the type of visual work to be performed. The amount of light required depends on the type of job being performed, i.e. the fineness of the work, the seeing times required, contrasts between materials being viewed, and the extent the light is absorbed by the materials. To achieve this condition the safety personnel should ensure that:

1. Surface illumination is both adequate and uniform with a brightness of light equally distributed in the surrounding space.
2. Workplace is lighted to give workers a clear vision of the process, tool or work-piece at a distance of more than 0.5 meter to the eye.
3. The light source is free of glare, the spectral distribution of light is favorable, and the lights beams have a proper incident direction.
4. The light provides uniform illumination on work surface, and fluctuations, pulsations and abrupt changes of luminance are absent.
5. Lighting ensures minimization and elimination of any visual discomfort or dazzling condition or direct glare.
6. Lighting ensures elimination of very undesirable reflected glare from illuminated surfaces in the directions of worker's eyes.

Glare: It is a condition of vision in which there is *discomfort or reduction* in the ability to see significant objects, or both due to an *unsuitable distribution or range of luminance* or *extreme contrasts* in space and time. Obviously, one of the important requirements of good lighting is that it should be free from excessive glare caused by light sources. Glare may be viewed through windows or roof light, or the lighting fittings in the room. They may be:

- a) Direct due to light sources within the field of vision;
- b) Reflected from light sources or bright polished surfaces; and
- c) Veiling where the peripheral field is comparatively very bright.



Light from luminaries can be (a) direct; (b) reflected; and (c) diffuse

Glare does not always make an immediate effect on worker's health. Its deleterious effects become evident only after long hours of sustained work in glare producing condition. Under the high levels of illumination, little or no disability to vision may occur. But there *can be serious discomfort to sight due to the complex action of the brightness size and position of light surroundings*. Glare may be intolerable where the occupation demands the workers to remain seated in one position and their normal vision limited to a fixed direction like in office work, watch making and repairing operation etc., than where occupation requires a worker to move about or where the line of sight of occupants is changing. Sensitivity to glare discomfort varies considerably between individuals. Good lighting demands that the degree of glare be limited to an amount acceptable to the majority of people using the building.

Glare Index represents the amount of discomfort glare in a lighting installation. This may be derived from a basic formula, but the procedure is lengthy.

Lighting for movement about a building: Most industrial buildings are complexes of working areas and other areas, such as passages, corridors, stairways, lobbies and entrances. The lighting of these areas is properly correlated during design stage itself and is required to be maintained effectively so that workers can move within the building safely at all times. Accident may result if people leave a well-lighted working area and enter immediately on to a stairway where the lighting is inadequate, because in such cases the adaptation time needed for good sight may be long enough to see trades of stairway quickly. It is therefore desirable that the illumination of areas that open on to a working area should be maintained fairly high in spite of the fact that they are used only occasionally.

COLOUR RENDERING: The appearance of coloured surfaces depends on (a) their reflection characteristics, and (b) on the spectral composition of the light illuminating them. Good colour rendering is important in a building on the grounds of amenity (pleasantness of place) and improved visual efficiency that facilitates better the recognition of task detail. In some occupations correct and constant colour rendering is essential to the performance of work. One example is the operation theatre of a hospital where true colour rendering is highly important. In some occupations, such as cotton grading or colour matching of paints, critical colour judgments and comparisons are necessary. For this type of works artificial lighting systems are preferred to natural lighting because this could be designed with advantage to provide a light that is constant in quantity and quality at all times. Frequent changes in characteristics of natural lighting with respect to seasons and day-time limit its use in such important occupations.

DESIGN OF INDUSTRIAL LIGHTING INSTALLATION: Correct lighting adequate for the job requirement is to be properly designed and installed. This is an important factor in accident prevention. The selection of proper lighting equipment and fittings and their placement are essential features to give optimum results. They are decided by the lighting engineers. Certain general information is, however, useful to safety specialists in order to evaluate existing condition and future needs. Plant illumination consists of four types:

1. *General Lighting* – This system usually consists of light sources distributed 10 feet or more above the floor. The light produced by general lighting should be uniform at all locations of the workplace.
2. *Localized Lighting* – Certain operations which are special in nature are located in places where uniform distribution of light is not necessary. It is essential in such cases to direct the light to the machine or work-bench. Effect of local lighting is relatively intense in quantity. It also provides illumination to the adjacent surroundings at the same time.
3. *Supplementary Lighting* – Jobs that are fine and difficult to see, such as precision operations and fine bench-work e.g. radio and telephone assembly, needs a better quantity and higher quality of light than economically obtained by installing general and localized lighting. Supplementary lights are therefore provided and located so that excessive glare is not created.
4. *Emergency Lighting* – Emergency lighting is an important face of the illumination from the point of view of safety. It is concerned with the provision of illumination for important stairways, workplaces and exits in the event of regular lighting services for the factory fails. In plants & factories where manufacturing process takes place, emergency lighting should be provided under the following circumstances:
 - To continue operations where failures of normal lights may be conducive to accident (fire, explosion or poisoning). Failure of normal lighting may cause mal-operations and undesir able changes in the process of manufacturing.
 - To evacuate people from workrooms if failure of normal lighting may be conducive to accident from machines and equipment or the workroom has places that are dangerous for passage of people;
 - At places, such as gangways, staircases, traffic and sideways, where a risk of stumbling or falling exists.

The standard minimum of illumination that emergency lighting should provide if normal light fails is not less than 0.5 lux measured on the floor surface, and not less than 0.2 lux, on the open ground.

The emergency system operates from a independent power source viz. battery set or diesel generator set etc., which has automatic, self-actuating arrangement. Places of public importance such as auditorium or assembly hall, cafeterias etc., where more than 100 people may assemble at one time, are provided with emergency lighting inside the hall and at the exit points for safety and protection of common people.

Maintenance of Lighting Installations: Unless both the structure of a building and the lighting equipment are well maintained, the aims of good lighting will be defeated in no time. The lighting, natural or artificial, will not fulfill its purpose fully. The cost of providing useful light will increase. The appearance of the building structure will deteriorate. The problems with good maintenance are many and varied. They vary from situation to situation, from industry to

industry. In chemical Industries and Thermal Power Plants such maintenance is highly difficult and costly. A properly planned and drawn out maintenance program for an industry is always desirable for plants structure i.e. room surfaces, windows or roof glazing as well as for artificial lighting equipment like lamps and fittings.

Film of dust and dirt that deposits on room surfaces and consequently reduces the reflection factors affect adversely the illumination of the room. Glossy surface depreciates less than matt surface and is easier to clean. They also give bright reflection which is troublesome. One should therefore choose to use smooth but non-glossy stain finish for wall and ceiling.

In some industries viz. Coal based Thermal power plant, Cement plant or Sinter making unit of Iron & Steel Plant the dust and dirt deposits may be heavy. It may be difficult to remove them by normal cleaning process. Roof lights (natural) in which the glazing is horizontal or slopped at a small angle may collect dirt at faster rate than a vertical glazing one. They require more frequent cleaning. In practice, however, the cleaning is less because of their inaccessibility. The building gets lower light than intended during design.

The efficiency of artificial lighting equipment decreases progressively with time due to:

1. Gradual fall in light output of the lamps;
2. Fall in efficiency of fitting caused by deposits of dust/dirt on transmitting or reflecting surfaces; and
3. Permanent discoloration of the transmitting and reflecting surfaces with the age.

Good maintenances of lighting system therefore calls for *replacement of lamps* when they pass their economically useful life and for *regular cleaning and servicing* of the lighting

RECOMMENDED VALUES OF ILLUMINATION ‘National building code of India 1983’ recommends values of illumination related to occupations and building commensurate with the general standards of lighting. These are valid under the conditions whether the illuminations are natural, artificial or a combination of the two. They can be exceeded where the standards, of visual performance or amenity, required are higher than those set in the recommendation. Where a visual task is required to be carried out in the interior of an industry the working plan for the purpose of general illumination levels is considered on workplace which are 75 cm above floor levels. Where the task is localized, the recommended value is for task only. It should not be considered for the general level of illumination of entire interior.

SERIAL NOS.	VISUAL TASKS	ILLUMINATION (LUX)
1	<i>Industrial Building and Processes</i>	
	Canteen	150
	Clock-room	100
	Entrances, corridors, stairs	100
	<i>Factories Outdoor Ares</i>	
	Stockyard, main entrances and exit roads, car parks, internal factory roads	20
	<i>Assembly shops</i>	
	Rough works e.g. Frame assembly and assembly of heavy machinery	150
	Medium work e.g. engine assembly, vehicle body assembly	300
	Fine work e.g. radio and telephone	

equipment, type writer assembly	700
Very fine work e.g. very small precision mechanism and instrument	1500

Industrial Boiler Houses

Coal and Ash handling	100
Boiler room front	100
Other Areas	20 - 50

Chemical Works

Boiling tanks, stationary driers, crystallizers, mechanical driers, evaporators, filtration plants, extractors, percolators, electrolytic cells, nitrators etc.	150
Controls, gauges, valves, etc.	100
Control rooms	200 - 300

Electric Generation Stations (indoor)

Turbine halls	200
Auxiliary equipment, battery rooms, blowers, auxiliary generators, switchgear and transformer chambers	100
Boiler houses including operating floor, coal conveyors, pulverizers, feeders, precipitators, soot and slag blowers	70-100
Basements	70
Conveyor houses, gantries, and junction Towers	70-100
Control rooms	200-300

Foundries

Charging floors, cleaning, pouring, shaking out, rough moulding and rough core making	150
Fine moulding, core making and inspection	300

Iron and steel works

Marshalling and outdoor stockyards	10-20
Stairs, gangways, basements, loading docks	100
Slab yards, melting shops, ingot stripping, Soaking pits, blast-furnace working areas, Picking line, mechanical plant and pump houses	700
Rolling and wire mills, mill motor rooms,	

power and blower houses	150
Plate inspection yards	300

Laboratories and test rooms

General laboratories and balance room	300
Electrical and instrument laboratory	450

Welding and Soldering

Gas and arc welding and rough spot Welding	150
Medium soldering, brazing and spot Welding e.g. domestic hardware	300
Fine welding and spot welding e.g. instruments, radio set assembly	700

Machine and Fitting Shops

Rough bench and machine work	150
Medium bench and machine work, fine automatic machines, medium grinding, fine buffing and polishing	300
Fine bench and machine work, medium grinding, fine buffing and polishing	700

Paint Works

General, automatic processes	300
Batch mixing	450
Colour matching	700

RELEVANT EXCERPTS FROM THE REPORT OF THE COMPETENT PERSON SUBMITTED TO THE GOVERNMENT ARE REPRODUCED HEREUNDER

During the year in a Public Sector Unit an accident occurred when a thick crust formed over the molten metal was thrown out along with molten metal from a 2.5 Metric Tonne Capacity Induction Coil Heating Steel Melting Furnace, causing severe burn injuries to the near-by workers. Nine of them succumbed to the injuries later on. The crust and the molten metal flashed out when the operating personnel attempted to break the said crust.

Considering the gravity of the situation the State Government appointed a Competent person under section 90 of the Factories Act, 1948 vide G. O. No. 636-LW
LW/2A-1/92

dated 23. 7. 92 to enquire into the causes and the circumstances leading to the accident as well as to suggest steps and measures necessary to prevent occurrence of such accident in future.

1. Dr. Madhusudan Bhattacharyya Competent Person
Prof. and Head of the Deptt. of Mechanical Engineering,
Jadavpur University, Calcutta-32
2. Shri R. N. Bagchi, Assessor
Chief Executive, EMBCON
2/13, Ashoke Nagar, Calcutta-42
3. Shri A. K. Agarwal, I.A.S. Assessor
Jt. Secretary to the Govt. of West Bengal, Labour Deptt.
Writers' Buildings Calcutta-700 001.
4. Shri S. K. Bhattacharyya Convener & Assessor of
Jt. Chief Inspector of Factories, West Bengal the Inquiry Committee.
New Secretariat Buildings, (8th fl.)
1, K. S. Roy Road, Cal-700 001.

Relevant excerpts from the Report of the Competent Person submitted to the Government are reproduced hereunder :-

5. CIRCUMSTANCES LEADING TO THE ACCIDENT

It transpired during investigation and on perusal of the Operating Log Book for 20. 7. 92 that the Furnace was put into heating operation at about 1.15 p.m. with 100 kw power finally raised

to 1025 kw at 2.00 p.m. The Furnace was put to shut down from 2.15 p.m. to 3.08 p.m. for electrical maintenance to be carried out by the maintenance personnel of the G.E. C. Ltd., the supplier of the Furnace, as it was reported that the Furnace had a problem in its circuit breaker. The Furnace was restarted at 3.08 p.m. with 700kw power input. From 3.37 p.m. to 4.00 p.m. there was load shedding and the Furnace remained shut down. At 4.00 p.m. it was re-started with 850 kw power which was brought down to 200 kw at 4.05 p.m. for tea break. At 4.15 p.m. the power input to the Furnace was abruptly raised to 900 kw. The accident took place at about 4.45 p.m. while the operating personnel attempted to break down the crust formed over the molten metal in the Furnace.

6. Loss and Disaster Management

6.1 Loss of Life and Injury

Due to the accident 15 employees who were either on the charging platform of the Furnace or near the Furnace on the ground floor received burn injuries of various degree, viz, minor, serious and severe. Among them one of the employees died instantly at the spot. Fourteen other employees including one Officer were severely injured due to burn and were admitted in different Hospitals namely, ESI Hospital, Gourhati, Hooghly Sub-Divisional Hospital, Chandannagar, Calcutta Medical Research Institute, Calcutta and S.S.K.M. Hospital, Calcutta. Out of them eight persons died in different Hospitals within a week from the date of accident. Four persons were released from Hospital after treatment within a few days. Two employees having severe burn injury were under treatment at S.S.K.M. Hospital, Calcutta and were released on 15.10.92 and 25.11.92 respectively.

6.2 Management/Treatment of the Injured Persons

All the expenses towards treatment, blood transfusion, medicine in respect of the injured Persons etc. were borne by the Company till their release from the Hospitals.

6.3 Property Damage

During the accident there was also damage to property as noted below. These can either be repaired and/or replaced.

- One Sodium Vapour light fitting over the Furnace.
- The weighing scale on the charging platform.
- Charging floor.
- Electrical cables (440V power line & 230 V lighting cables).

6.4 Compensation

Besides ESI Compensation, an ex-gratia payment of Rs. 1 lakh each has been paid to the heirs of eight deceased employees and employments to their sons have also been provided by the Management. The case of one deceased employee could not be settled due to dispute regarding heirship.

A sum of Rs. 25,000/- and Rs. 3,000/- will also be paid to each employee having sustained serious and minor injury respectively.

7. Failure Analysis

7.1 Mechanism

Due to repeated shut down, a thick impervious top crust or skull consisting of an upper layer of slag non-magnetic by nature and subsequent layer of metal and metal-slag mix was formed which totally covered the furnace-pot. This prevented the release of gas emanating from the

molten metal underneath during the process of heating resulting in pressure build-up. The pressure of the gases so developed caused the skull to be thrown out and molten metal splashing out in the mode of volcanic eruption, while attempts were made to break the crust.

7.2. Causes of Pressure Rise

7.2.1 Explosion-reactions

These reactions are possible if ingress of water takes place in the Furnace due to leakage of water from the copper coil; in such case the side wall of rammed mass will be affected. Moreover, during melting stage it leads to the development of intense sound.

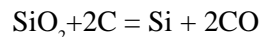
7.2.2 Volumetric Expansion

Volumetric Expansion of steel considering solid to liquid at pouring temperature is about 2%.

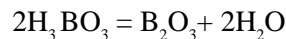
It is imperative that the pressure of the entrapped gas between the top skull and metal beneath will be increased due to the above volumetric expansion as the volume occupied by gas is reduced.

7.2.3 Evolution of Gases due to Chemical reaction or otherwise during melting

(1) The Silica used in ramming mass reacts in the following way at high temperatures :



(2) The boric acid (2%) used as binder with the ramming mass is dehydrated giving rise to water vapour



(3) Scrap used as charge may contain combustibles (oil, grease, jute, rags) and may not

(4) Be absolutely dry; this condition also favours the generation of gasses.

(5) Moreover, iron contains dissolved gases although in limited solubility. On melting this gas comes out.

(6) Metal oxide fumes or metal fume at high temperature of the Furnace present.

7.2.1 Impact Load due to poking of Top Crust

Just prior to the accident the operating personnel tried to break the crust by poking. This imparted impact loads on the molten metal when the peripheral seal got partially damaged through which pressurized entrapped gas escaped to the atmosphere at high velocity with attendant hissing sound. As gases escaped through one side, the skull was thrown upside down as if hinged at periphery diametrically opposite to the gas passage.

7.3 Pressure Calculation

Total volume of Furnace holding liquid up to metal level = 0.36³m

On cooling to say 900°C the volume shrinkage may be taken to be = 0.36 × 1/100 = 0.0036m³. This space will be occupied by gases emanating out of various reactions in the process of melting.

When the temperature is raised to about 1680°C, the entrapped gas tries to expand.

Neglecting the volumetric expansion of metal, the pressure at 1680°C can be calculated from the formula-

$$\frac{PV}{T} = \text{a constant}$$

It can be written as $P_1 V_1 = P_2 V_2$

$$T_1 \quad T_2$$

Where, P_1 = Initial pressure at 900°C

V_1 = Initial volume occupied by the gas at 900°C

T_1 = 900 + 273 = 1173 K

P_2 = Final Pressure at 1680°C

V_2 = Final volume at 1680°C

V_1 = (taken) neglecting the volumetric expansion of steel.

And assuming that $T_2 = (1680 + 273) \text{ K} = 1953 \text{ K}$ (although a much higher temperature is likely to be attained due to heating at 900kw for 15 minutes during the last phase of operation prior to the accident)

$$P_2 = 1.013 \times 1153 / 11736 \text{ } 10^5 \text{ Pa} = 0.167 \text{ MPa}$$

Actually P_2 will be much higher if the volumetric expansion of steel is taken cognizance of.

Actual weight of the skull (625mm to 630mm in diameter and thickness varying from 170mm to 80mm) = 233kg. (Photo in Page 63)

The gas pressure required to eject the skull from the Furnace-pot, considering a total friction drag equivalent to the self weight of the skull.

$$= 2 \times 233 \times 9.81 \quad \text{N} = 0.0119 \text{ MPa}$$

It is evident that the pressure rise in the chamber is more than what is needed to lift the skull off the Furnace-pot and this actually occurred.

Initial pressure required to strip the metal skull off the Furnace wall will actually be considerably larger as on solidification there is adherence between the skull and Furnace well interface. Even with all these considerations it can be predicted that the gas pressure of 0.167

(MPa) which is 0.167 = 14 times the pressure needed to lift the metal slag chunk is

sufficient to eject the same and to cause virulent splashing of molten metal resembling volcanic eruption.

8. Recommendations Pertaining to Induction Furnace

8.1 Electrical Check

- (1) Earthing of all exposed metal parts of the Furnace structure is a must. The continuity of earthing should be tested at regular intervals.
- (2) The insulation resistance of the whole installation should be tested preferably before every heat.
- (3) Loose electrical connections and short circuiting at different points should be prevented.
- (4) The capacitor banks are to be checked during power failure to prevent explosions.

8.2 Cooling Water Check

- (1) Water quality, DM water and raw water, should be confirm to the specifications as given in G.E.C's Operating and Instructions for MF Coreless Induction Melting Furnaces.
- (2) Water leakage checking at hoses is mandatory.
- (3) Checking for water leakage at the copper cooling coil of the A Furnace has to be done before every cold starting of the furnace.

8.3 Furnace Lining

The lining should be installed as per refractory manufactures instructions. It is essentials that these are strictly adhered to. For ramming mass the detailed instructions for application of lining as given

in G.E.C.'s Operating and Maintenance Instructions for Medium Frequency Coreless Induction Melting Furnaces (Section III: Furnace Lining and Sintering, P 4 to 7) and the manufacturer of the ramming mass materials should be strictly adhered to.

8.4 Furnace Operations

- (1) Follow the instructions given in the G.E.C.'s Operating and Maintenance Instructions for Medium Frequency Coreless Induction Melting Furnaces (Section : VIII, Operation P 15 to 17).
- (2) Use dry charge free of grease, oil not accompanied with rags, jute etc
- (3) Skim off all the slag by shallow graphite covered spoons, particularly when the power is shut off. In the present case although no Ferromanganese, Ferrosilicon etc. were added, the slag present in the skull is considerable, which points out to the poor quality of charge added to the furnace.

Actual volume of the skull=40.5l

Volume of slag, V_s + Volume of steel, $V_I=105 \dots (i)$

Again, $7.8 V_i + 2.8 V_s = 233 \dots$ (ii)

2.8 being the weight of slag in kg/l

From equation (i) and (ii),

Solified Slag Volume, $V_s = 16.1$

and solified volume of steel, $V_i = 23.91$

Theoretical thickness of top slag layer in skull = $16.6 \times 1000 \text{ cm} = 13 \text{ mm}$ and thickness

$$\frac{\pi \times 70^2}{4}$$

of bottom layer of metal in skull = 62 mm. Actually, the skull thickness was not even all through and gas cavities on the bottom of the skull were clearly visible.

(4) In case of power failure/shut down for exigency maintenance, steps be taken to empty the Furnace as soon as possible. If emptying is not possible, skim off the slag, tilt the Furnace at about 15° to the vertical, add some fluxes e.g. dry lime stone on the top to remain the fluidity of remaining slag for a little longer period and in the meantime insert a crowbar through slag/ metal at the top before getting solified to allow passage for gas to come out. The Furnace can be restarted later with very slow rate of heating in the tilted position. Maintenance of a suitable size vent hole for escape of trapped gas will also prevent pressure rise.

THE BEST PRACTICE IS TO EMPTY THE POT IN CASE IF POWER INTERRUPTION

8.5 Ladle Operation

Use properly Checked bottom pouring ladle; graphite stopper needs careful attention.

8.6 General Remark

- (1) The operator must use insulated tools, or switch off power, when making contact with the charge.
- (2) When using dry ramming material to line the Furnaces, use dust control procedures i.e. face masks or similar safety precaution should be taken.
- (3) To avoid secondary or boil-over, make sure that the charge is dry. The bundled charge, if used, should be dried before adding. Closed tins or containers containing liquids must not be added.
- (4) Do not look directly into the Furnace if it contains molten metal without using suitable eye protection.
- (5) The thickness of the rammed mass should be measured prior to each charge. It should not go below 60% of the initial thickness. This is necessary to prevent accident by bursting the rammed shell.
- (6) Be careful to arrange for venting through the slag or slag-metal mix on the top to avoid accident of the present nature. Remember that slag is non-magnetic and therefore once solified this melts only by heat-conduction from the hot metal below. Therefore, skim off slag when the power is off as suggested earlier.
- (7) Persons working in the Furnace should put on safety shoes, asbestos aprons and hand gloves, fire resistance helmets and safety goggles.
- (8) Suitable fire fighting tackles should be kept in the vicinity of the Furnace.

(9) The portion [as shown in Drg. No. TRFI/G-28/008 (modified)] of mould transfer car pit be covered with chequered plate or the like. The rail lines are embedded in concrete as shown. This will provide for easy escape route for Furnace personnel in case of exigencies.

(10) The spillage-pits as shown in GEC'S Drg. No. AI-13351 should be arranged for.

(11) Remember that the best safety device is the deployment of intelligent and well instructed operators who have thoroughly familiarized themselves with the operation of the equipment. To this end, it is highly desirable that persons be identified for Furnace operation and related work and training, theoretical and practical, be arranged under the supervision of competent person/s for a suitable period till confidence is inculcated among the operators-to-be. This is of paramount importance to wipe out the nightmarish experience of the fatal accident.

(12) A distinct line of command for the furnace operation as a whole be established.

(13) While in operation, the Furnace must not be left unattended.

9. Specific observations related to equipment and appliances inspected.

The committee inspected the factory on 17.12.92 and 18.12.92 to assess the general safety status of the factory. The following recommendations are made based on the said assessment.

(1) Illumination level in the factory in general and in particular in some work-places including foundry shop was observed to be inadequate. Necessary arrangement should be made to increase illumination to a level as prescribed under the statute/standard.

(2) From the perusal of the test certificate made by the Competent Person in respect of testing of the lifting machines and tackles used in the factory, it was observed that most of them had some defects. The defects shall be rectified and the fresh certificate obtained in respect of them. Subsequent testing shall also be done regularly at such interval as stipulated under the statute.

(3) Test certificate of the Compressed air receiver and other pressure vessels shall be tested immediately as per statute and subsequently at such regular interval as prescribed.

(4) In the Fabrication Shop, the brake off the EOT crane No.27 was observed to slip. The defect shall be immediately rectified.

(5) Rubber pipelines in the Oxy-cutter and Gas Welding Torch in the Fabrication Shop were found damaged. Pipelines shall be immediately replaced by standard rubber pipe.

(6) Electrical switch-boards and the supply line were observed to be damaged, particularly in the foundry shop. They shall be properly rectified and also tested by Licensed Contractor.

(7) Corrugated G.I. roof of the Foundry shop was observed to be damaged at several places. They shall be thoroughly repaired immediately so as to prevent the possibility of rain water dripping on molten metal which may result in explosion.

(8) The discharge air line of the new compressor No.255 was observed to be clogged due to deposition of oil and dirt for inadequate cooling as the after-cooler system of the compressor was by-passed. The said after-cooler arrangement for all the compressors shall be installed immediately.

(9) The wheel alignment on the rail for the 10 ton EOT Crane No.23 in the Fabrication shop was observed to be not in order causing vibration and electrical sparks during movement. The defect shall be immediately rectified. Other EOT Cranes shall also be checked for their alignment.

(10) Hankoline Oxy-cutter machine in the Fabrication shop was observed to be not properly maintained.

(11) Adequate number of fire extinguisher of prescribed types per statute shall be provided in the factory.

(12) General house-keeping and cleanliness in the factory, in particular in the foundry shop was far from satisfactory.

(13) The noise level in the Pneumatic Chipping Machine was found to be intense. The noise level should be reduced by proper attenuation. Suitable ear muff should be provided to those persons likely to be exposed.

(14) The welding areas should be properly ventilated as well as separated from other work area so as to prevent inhalation of toxic gases and fumes generated during welding by the operators/ persons working near-by.

10. General Recommendations Pertaining to Works as a Whole

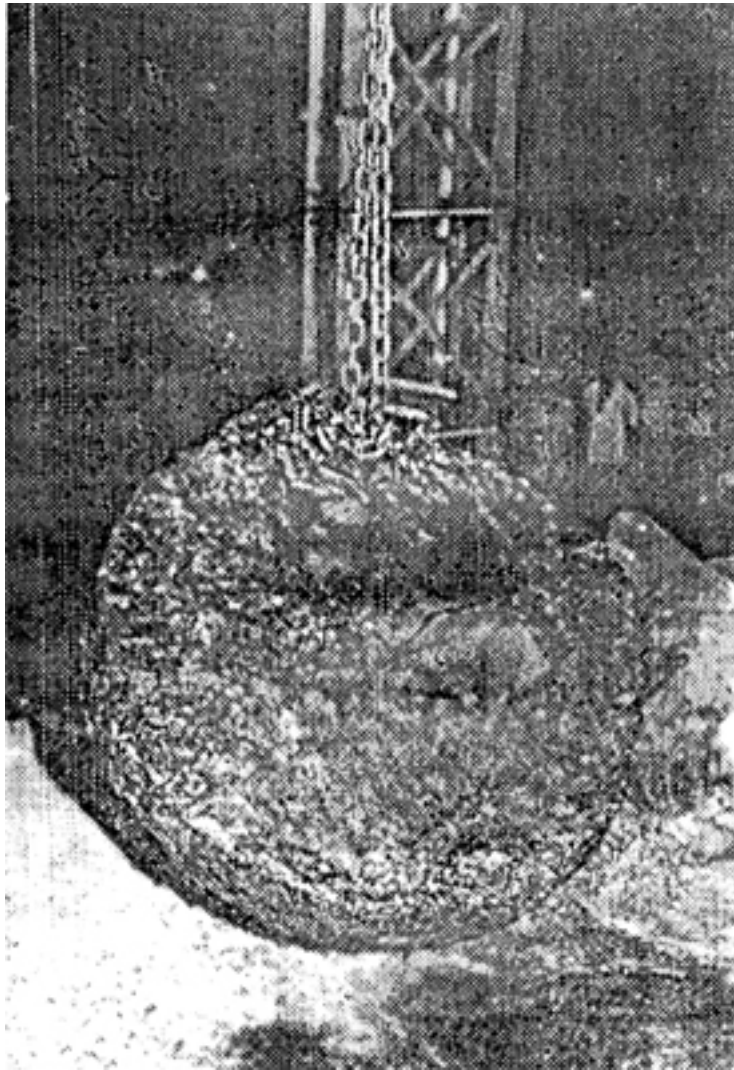
Recommendations listed below have been categorized in two classes, one involving practically finance and other requiring sizeable investment.

- (1) Check earthing connections.
- (2) Test the electrical lines.
- (3) Provide top covers to all electrical switch boxes on columns.
- (4) Interlocked plugs are preferable.
- (5) Safeguard the transmission machinery and other dangerous moving parts of all machines.
- (6) Remove the workers' lockers from center of shops to side walls to avoid obstructions in movement, specially in foundry.
- (7) Remove all redundant mould boxes, patterns and rubbish from foundry; stack mould boxes and patterns orderly.
- (8) Keep gangways clean. Allow no cycle in the shops.
- (9) Cover the section of trolley trenches, pits etc in foundry not in use.
- (10) Stack materials properly in shops.
- (11) Regularly check and appliances like gas torches, safety shut off valves of furnaces.
- (12) Keep fire fighting equipment workable.
- (13) Disallow lighting of fires in winter in the shops.
- (14) Arrange for regular maintenance and testing of cranes, overhead cranes in particular.
- (15) Check the Pneumatic line and any pressure vessel containing gaseous matters in particular.
- (16) Reduce stray dog menace from the shop floor-ask people not to feed the dog with canteen refuse inside the shop.
- (17) Provide personal protection equipment e.g. respiratory appliances, safety shoes, heat protective overalls, hand gloves, safety goggles, welding shields, helmets etc.
- (18) Pay careful attention to fuel storage facilities, piping, equipment and burner to prevent fire and explosion. Observe appropriate measure to prevent flash back in oil fired furnaces.
- (19) Keep ambulance ready at hand.

10.2 Financial involvement is moderate to significant

- (1) Provide adequate illumination in shops and gangways.
- (2) Install emergency lamps in shops at evening shifts in case of power cut.
- (3) Rewire defective electrical lines, canteen hall and kitchen in particular.
- (4) Change the damaged switch boxes mounted on columns.
- (5) Repair the damaged roof sheets, particularly in Foundry Shop to prevent the possibility of explosion due to dropping of water on molten metal.

(As published in Labour in West Bengal, 1992, Department of Labour, Government of West Bengal)



(Skull)

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