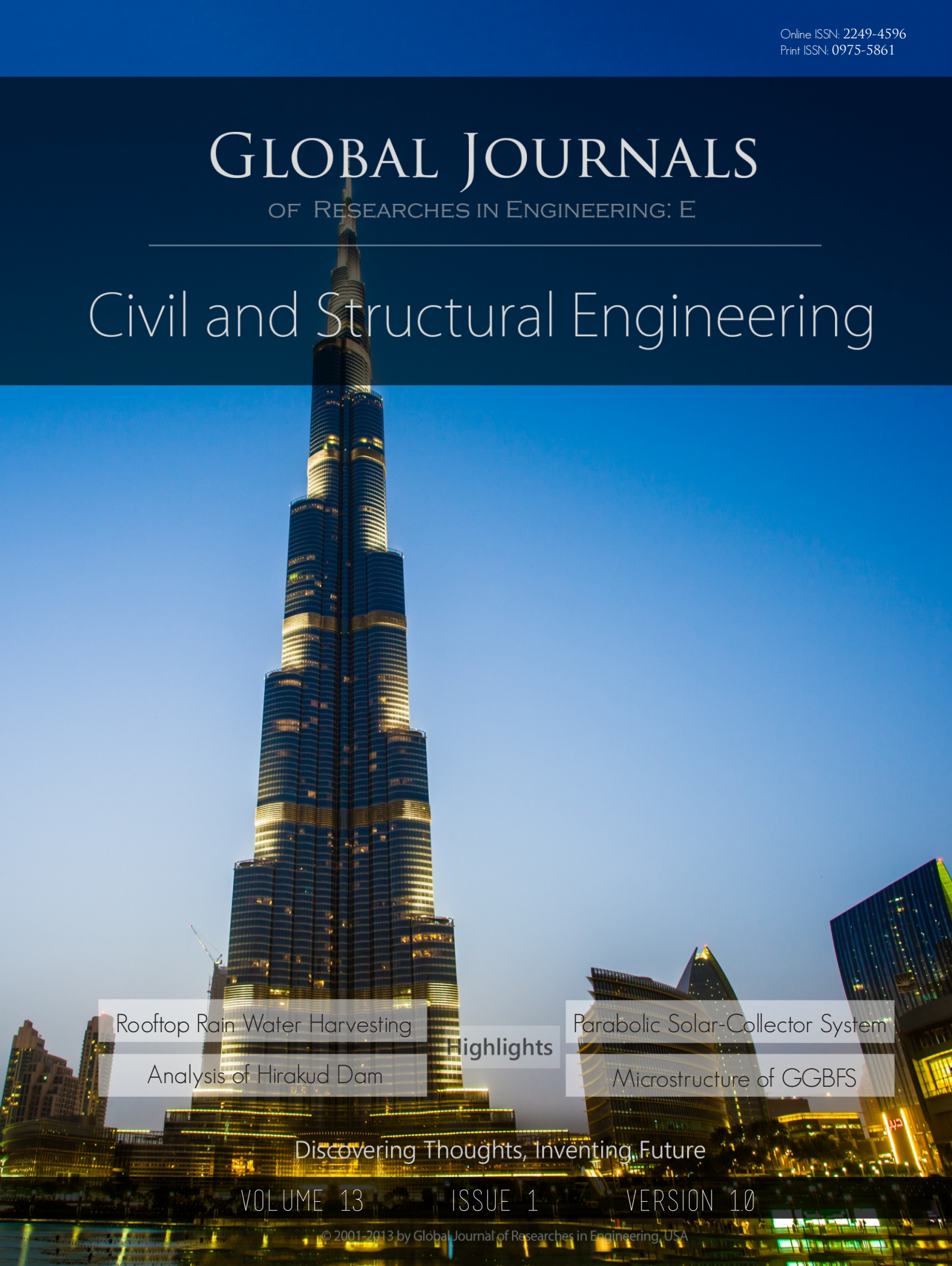
Online ISSN: 2249-4596
Print ISSN: 0975-5861

Global Journals

of Researches in Engineering: E

Civil and Structural Engineering



Rooftop Rain Water Harvesting

Analysis of Hirakud Dam

Highlights

Parabolic Solar-Collector System

Microstructure of GGBFS

Discovering Thoughts, Inventing Future

VOLUME 13 ISSUE 1 VERSION 1.0

Global Journal of Researches in Engineering: E
Civil And Structural Engineering

Global Journal of Researches in Engineering: E
Civil And Structural Engineering
Volume 13 Issue 1 (Ver. 1.0)

Open Association of Research Society

Incorporation No.: 0423089
License No.: 42125/022010/1186
Registration No.: 430374
Import-Export Code: 1109007027
Employer Identification Number (EIN):
USA Tax ID: 98-0673427

Global Journals Inc.

*(A Delaware USA Incorporation with "Good Standing"; **Reg. Number: 0423089**)*

Sponsors: Open Association of Research Society
Open Scientific Standards

Publisher's Headquarters office

Global Journals Inc., Headquarters Corporate Office, Cambridge Office Center, II Canal Park, Floor No. 5th, ***Cambridge (Massachusetts)***, Pin: MA 02141 United States
USA Toll Free: +001-888-839-7392
USA Toll Free Fax: +001-888-839-7392

Offset Typesetting

Open Association of Research Society, Marsh Road, Rainham, Essex, London RM13 8EU
United Kingdom.

Packaging & Continental Dispatching

Global Journals, India

Find a correspondence nodal officer near you

To find nodal officer of your country, please email us at *local@globaljournals.org*

eContacts

Press Inquiries: *press@globaljournals.org*
Investor Inquiries: *investers@globaljournals.org*
Technical Support: *technology@globaljournals.org*
Media & Releases: *media@globaljournals.org*

Pricing (Including by Air Parcel Charges):

For Authors:
22 USD (B/W) & 50 USD (Color)
Yearly Subscription (Personal & Institutional):
200 USD (B/W) & 250 USD (Color)

Editorial Board Members (HON.)

Dr. Bart Lambrecht
Director of Research in Accounting and FinanceProfessor of Finance
Lancaster University Management School
BA (Antwerp); MPhil, MA, PhD (Cambridge)

Dr. Carlos García Pont
Associate Professor of Marketing
IESE Business School, University of Navarra
Doctor of Philosophy (Management), Massachusetts Institute of Technology (MIT)
Master in Business Administration, IESE, University of Navarra
Degree in Industrial Engineering, Universitat Politècnica de Catalunya

Dr. Fotini Labropulu
Mathematics - Luther College
University of ReginaPh.D., M.Sc. in Mathematics
B.A. (Honors) in Mathematics
University of Windso

Dr. Lynn Lim
Reader in Business and Marketing
Roehampton University, London
BCom, PGDip, MBA (Distinction), PhD, FHEA

Dr. Mihaly Mezei
ASSOCIATE PROFESSOR
Department of Structural and Chemical Biology, Mount Sinai School of Medical Center
Ph.D., Etvs Lornd University
Postdoctoral Training,
New York University

Dr. Söhnke M. Bartram
Department of Accounting and FinanceLancaster University Management SchoolPh.D. (WHU Koblenz)
MBA/BBA (University of Saarbrücken)

Dr. Miguel Angel Ariño
Professor of Decision Sciences
IESE Business School
Barcelona, Spain (Universidad de Navarra)
CEIBS (China Europe International Business School).
Beijing, Shanghai and Shenzhen
Ph.D. in Mathematics
University of Barcelona
BA in Mathematics (Licenciatura)
University of Barcelona

Philip G. Moscoso
Technology and Operations Management
IESE Business School, University of Navarra
Ph.D in Industrial Engineering and Management, ETH Zurich
M.Sc. in Chemical Engineering, ETH Zurich

Dr. Sanjay Dixit, M.D.
Director, EP Laboratories, Philadelphia VA Medical Center
Cardiovascular Medicine - Cardiac Arrhythmia
Univ of Penn School of Medicine

Dr. Han-Xiang Deng
MD., Ph.D
Associate Professor and Research
Department Division of Neuromuscular Medicine
Davee Department of Neurology and Clinical NeuroscienceNorthwestern University
Feinberg School of Medicine

Dr. Pina C. Sanelli
Associate Professor of Public Health
Weill Cornell Medical College
Associate Attending Radiologist
NewYork-Presbyterian Hospital
MRI, MRA, CT, and CTA
Neuroradiology and Diagnostic Radiology
M.D., State University of New York at Buffalo,School of Medicine and Biomedical Sciences

Dr. Roberto Sanchez
Associate Professor
Department of Structural and Chemical Biology
Mount Sinai School of Medicine
Ph.D., The Rockefeller University

Dr. Wen-Yih Sun
Professor of Earth and Atmospheric SciencesPurdue University Director
National Center for Typhoon and Flooding Research, Taiwan
University Chair Professor
Department of Atmospheric Sciences, National Central University, Chung-Li, TaiwanUniversity Chair Professor
Institute of Environmental Engineering, National Chiao Tung University, Hsin-chu, Taiwan.Ph.D., MS The University of Chicago, Geophysical Sciences
BS National Taiwan University, Atmospheric Sciences
Associate Professor of Radiology

Dr. Michael R. Rudnick
M.D., FACP
Associate Professor of Medicine
Chief, Renal Electrolyte and Hypertension Division (PMC)
Penn Medicine, University of Pennsylvania
Presbyterian Medical Center, Philadelphia
Nephrology and Internal Medicine
Certified by the American Board of Internal Medicine

Dr. Bassey Benjamin Esu
B.Sc. Marketing; MBA Marketing; Ph.D Marketing
Lecturer, Department of Marketing, University of Calabar
Tourism Consultant, Cross River State Tourism Development Department
Co-ordinator , Sustainable Tourism Initiative, Calabar, Nigeria

Dr. Aziz M. Barbar, Ph.D.
IEEE Senior Member
Chairperson, Department of Computer Science
AUST - American University of Science & Technology
Alfred Naccash Avenue – Ashrafieh

President Editor (HON.)

Chief Author (HON.)

Dean & Editor-in-Chief (HON.)

Contents of the Volume

Global Journal of Researches in Engineering
Civil And Structural Engineering
Volume 13 Issue 1 Version 1.0 Year 2013
Type: Double Blind Peer Reviewed International Research Journal
Publisher: Global Journals Inc. (USA)
Online ISSN: 2249-4596 & Print ISSN: 0975-5861

Dynamic Analysis of Hirakud Dam Due to Seismic Forces

By Gaurva Verma, Dr. M.K.Verma & Dr. R.K.Tripathi
Deptt.of Civil Engg, NIT, Raipur, India

Abstract - The present study investigates and analyses the behavior of a concrete gravity dam during the strong ground horizontal motions due to an earthquake with CADAM. The model in thesis is the structure of Hirakud gravity dam. Hirakud dam across river Mahanadi in eastern India is a composite structure of earth, concrete and masonry. Length of the main dam is 4.80 Km, flanked by 21 km earthen dykes on left and right sides, making a total length of 25.8km. Two concrete spillways of average height 45.75 m and maximum height 60.96 m are located in the two arms of the river. Hirakud dam has been built at Latitude 210-32' N and Longitude 830-52'E across river Mahanadi at about 15 km upstream of Sambalpur town. This is the first post independence major multipurpose river valley project in India. It hasn't ever shakes under the influence of powerful ground motions in the area. Because of lowness and special firmness of the structure it behaves like a solid body, therefore the structure should be compared with many different earthquake accelerations and then the maximum vibration of the body is considerable. After linear dynamic analysis with CADAM the results show the stresses on the body of the dam are relative to particularity of each earthquake like magnitude, epicenter distance and PGA .The body of dam is modeled two dimensional in CADAM.

Keywords : *dynamic analysis, concrete dam, seismic forces simulating.*

GJRE Classification : *FOR Code : 090506*

Strictly as per the compliance and regulations of :

Dynamic Analysis of Hirakud Dam Due to Seismic Forces

Gaurva Verma [α], Dr. M.K.Verma [σ] & Dr. R.K.Tripathi [ρ]

Abstract - The present study investigates and analyses the behavior of a concrete gravity dam during the strong ground horizontal motions due to an earthquake with CADAM. The model in thesis is the structure of Hirakud gravity dam. Hirakud dam across river Mahanadi in eastern India is a composite structure of earth, concrete and masonry. Length of the main dam is 4.80 Km, flanked by 21 km earthen dykes on left and right sides, making a total length of 25.8km. Two concrete spillways of average height 45.75 m and maximum height 60.96 m are located in the two arms of the river. Hirakud dam has been built at Latitude 21^0-32' N and Longitude 83^0-52'E across river Mahanadi at about 15 km upstream of Sambalpur town. This is the first post independence major multipurpose river valley project in India. It hasn't ever shakes under the influence of powerful ground motions in the area. Because of lowness and special firmness of the structure it behaves like a solid body, therefore the structure should be compared with many different earthquake accelerations and then the maximum vibration of the body is considerable. After linear dynamic analysis with CADAM the results show the stresses on the body of the dam are relative to particularity of each earthquake like magnitude, epicenter distance and PGA. The body of dam is modeled two dimensional in CADAM. The procedure of analyses is linear response spectra analysis. The acceleration records of ground motions in the CADAM dynamic response spectra analysis are real records of occurred earthquakes. The other data which are used in CADAM modeling are approximately unreal and exaggerated and they are used for magnifying the influence of earthquake on the dam's body.

Keywords : dynamic analysis, concrete dam, seismic forces simulating.

I. Introduction

Historically Odisha has experienced very few moderate to large earthquakes. Some events with magnitudes in excess of 5.0 have originated in the Bay of Bengal off the coast of the state. Several faults have been identified in the region and some have shown evidence of movement during the Holocene epoch. The Brahmani Fault in the vicinity of Bonaigarh is among then. The Mahanadi also flows through a graben structure. Several deep-seated faults are situated beneath the Mahanadi Delta. However, it must be stated that proximity to faults does not necessarily translate into a higher hazard as compared to areas located further away, as damage from earthquakes depends on numerous factors such as subsurface geology as well as adherence to the building codes.

Recognizing an earthquake behavior is of high importance. Previous earth quake experiences has shed light on the fact that in order to decrease the damages caused by earthquakes is only possible through in depth studies of previous earth quakes and also taking into consideration quake behavior of important structures. Concrete dames are of great importance because any damage can cause irreparable financial and causalities. Dynamic analysis of the concrete weight dams against external and internal forces has been the center of attention for Scientists and experts.

Present study is focused on dynamic analysis of concrete dam against difference forces caused by recent earthquakes. HassanMirza-Bozorg and MehdiVarmarziar in 2009 did a study in which they studied the effect of earthquake on the linear response of the concrete dam. The purpose of this study was to study the effect of non-uniform instigation tremulous on tremulous response of concrete dam and to compare it to uniform instigation which is common in analyzing and designing dams using the ABAQUES software. Chopra in 1991 studied the effect of earthquake on a weight dam conditional of the fact that there is a shaking floor under the dam. In this study the effect of earthquake on a rigid dam and a flexible dam was studied and several graphs were shown. Several problems that are a result of static analysis method are addressed. Various drawbacks include not considering: the structural elasticity, damping forces, variation of the foundation acceleration over time, and the alternation and short duration characteristics of the seismic loading. In Response Spectra analysis method the history of the structures behavior under the accelogram of the earthquake was studied and the forces, stresses and movements were calculated. In this study CADAM was used which is considered to be powerful software of this kind. For the purpose of response spectra records of real earthquakes such as earthquake on 12 June 2001 - Konokjora-Sundargarh area, Odisha, Mw 4.7, is used.

II. History

Dynamic analysis of concrete dam is more complicated compared to other buildings under the same conditions. ICOLD recommendations are followed

Author α: Research Scholar Deptt.of Civil Engg. NIT, Raipur, (C.G.) 492010, India. E-mail : gaurva.verma@gmail.com
Author σ: Professor Deptt.of Civil Engg NIT, Raipur, (C.G.) 492010, India. E-mail : mkseem670@gmail.com
Author ρ: Associated Professor Deptt.of Civil Engg NIT, Raipur, (C.G.) 492010, India. E-mail : rajesh_tripath64@yahoo.co.in

while evaluating the seismic parameters (ICOLD, 1989), therefore an Operating Basis Earthquake (OBE) and a Maximum Credible Earthquake (MCE) are considered. The seismic input is defined in terms of maximum horizontal accelerations and unified response spectra. Artificial acceleration time histories which are compatible with the response spectra are also provided and can be employed especially for non-linear analyses. McGuire´s relationship between magnitude, distance and ground acceleration is used when evaluating the maximum horizontal acceleration which is based on the earthquake-catalogue (Lenhardt, 1995). For the OBE, a return period of 200 years is selected with a minimum value of 0.6 m/s^2. For the MCE, not only the results of extreme-value statistics are considered, but also the global geology and long-term tectonic processes are taken into account. The resulting ground accelerations could be considered as approximate values only and, in general, more detailed studies including the local geological situation are necessary for a specific site. The maximum acceleration of the vertical excitation is defined as 2/3 of the respective maximum horizontal acceleration.

A pseudo-dynamic seismic analysis is based on the response spectra method. It is conceptually similar to a pseudo-static analysis except that it recognizes the dynamic amplification of the inertia forces along the height of the dam. However, the oscillatory nature of the amplified inertia forces is not considered. That is the stress and stability analyses are performed with the inertia forces continuously applied in the same direction. Since the pseudo-dynamic method does not recognize the oscillatory nature of earthquake loads it is also appropriate to perform the safety evaluation in two phases: (a)the stress analysis using peak spectral acceleration values, and (b) the stability analysis using sustained spectral acceleration values. It is assumed in these analyses that the dynamic amplification applies only to the horizontal rock acceleration. The period of vibration of the dam in the vertical direction is considered sufficiently small to neglect the amplification of vertical ground motions along the height of the dam.

a) The equations governing the lineal dynamic analysis of structures

For three-dimensional seismic motion, the typical modal Equation is written as:

$$\ddot{y}\ (t)n\ +\ 2\zeta n\omega n\,\dot{y}\ \ (t)n\ +\ \omega_n^2\ y(t)_n\ =\ p_{nx}\ u\ddot{}(t)_{gx}+\ p_{ny}\,\ddot{u}\,(t)gy+\ p_{nz}\ddot{u}(t)gz$$

Where the three *Mode Participation Factors* are defined by

$$\boldsymbol{p}ni\ \ = -\emptyset_n^T M_i$$

In which i is equal to x, y or z. Two major problems must be solved to obtain an approximate response spectrum solution to this equation. First, for each direction of ground motion, maximum peak forces and displacements must be estimated. Second, after the response for the three orthogonal directions has been solved, it is necessary to estimate the maximum response from the three components of earthquake motion acting at the same time. This section addresses the modal combination problem from one component of motion only.

For input in one direction only, Equation (15.1) is written as:

$$\ddot{y}(t)_n\ +\ 2\zeta_n\omega_n\dot{y}(t)_n\ +\ \omega_n^2\ y(t)_n=\ p_{ni}\ \ddot{u}\ (t)_g$$

Given a specified ground motion $\ddot{u}\ (t)_g$, damping value and assuming *Pni*= -1.0, it is possible to solve the Equation at various values of ω and plot a curve of the maximum peak response $(\omega)MAX$. For this acceleration input, the curve is by definition the ***displacement response spectrum*** for the earthquake motion. A different curve will exist for each different value of damping.

A plot of $\omega y(\omega)MAX$ is defined as the ***pseudo-velocity spectrum*** and a plot of $\omega^2 y(\omega\ )MAX$ is defined as the ***pseudo-acceleration spectrum.***

The three curves-displacement response spectrum, pseudo-velocity spectrum, and pseudo-acceleration spectrum are normally plotted as one curve on special log paper. However, the pseudo-values have minimum physical significance and are not an essential part of a response spectrum analysis. The true values for maximum velocity and acceleration are calculated from the solution of Equation (15.2). There is a mathematical relationship, however, between the pseudo-acceleration spectrum and the total acceleration spectrum. The total acceleration of the unit mass, single degree-of-freedom system, governed by Equation (15.2), is given by:

$$\ddot{u}(t)\ =\ \ddot{y}\ (t)\ +\ \ddot{u}\ (t)_g$$

Equation (15.2) can be solved for $\ddot{y}(t)$ and substituted into Equation (15.3) to yield:

$$\ddot{u}(t)T\ =-\omega^2(t)-2\ \xi\omega\dot{y}(t)$$

Therefore, for the special case of zero damping, the total acceleration of the system is equal to $\omega^2 y(t)$. For this reason, the ***displacement response spectrum*** curve is normally not plotted as modal displacement $y(\omega)MAX$ versus ω. It is standard to present the curve in terms of $S(\omega)$ versus a period T in seconds,

Where:

$$S(\omega\ )a\ =-(\ \omega)^2 y(\omega)MAX$$

and

$$\frac{2\pi}{\omega}$$

The pseudo-acceleration spectrum curve, $S(\omega)a$, has the units of acceleration versus period that has some physical significance for zero damping only. It is apparent that all response spectrum curves represent the properties of the earthquake at a specific site and are not a function of the properties of the structural system. After an estimation is made of the linear viscous damping properties of the structure, a specific response spectrum curve is selected.

III. Modeling the Dams System and Foundation

The Hirakud Dam is a composite structure of earth, concrete and masonry. Ten km north of Sambalpur, it is the longest major earthen dam in the world, measuring 24 km including dykes, and stands across the river Mahanadi. The main dam has an overall length of 4.8 km spanning between two hills; the Lamdungri on the left and the Chandili Dunguri on the right. The dam is flanked by 21 km earthen dykes on both the left and right sides, closing the low saddles beyond the adjoining hills. The dam and dykes together measure 25.8 km. It also forms the biggest artificial lake in Asia, with a reservoir holding 743 km^2 at full capacity, with a shoreline of over 640 km.

The building of the dam in spite of its great height and its hardness shows a strong behavior under horizontal movements, because of this in the below study the modeling was done under the acceleration of several earthquakes so that we can study the maximum vibration.

The study area lies between 17° to 24°N, 78°o 88°E and a simplified geology map (Sarkar, 2001) with main tectonic elements (GSI, 2000) is shown in Fig. 1. The Bastar craton [BB] is separated from the Dharwar [DB] and Singhbhum cratons [SB] by the Godavari [GG] and Mahanadi [MG] Gondwana grabens respectively; with the Eastern Ghat Mobile belts [EGMB] lying to the south east. From detailed geological, petrological and structural studies the Central Indian shear (CIS, Yedekar *et al.*, 1990) has been identified, which separates the Bastar block from the northern (Bundelkhand) block. The western side of this shear is buried under alluvium and traps while to the east it forks into two parts with the northern part coming close to the Tan shear. From geological and geochronological data the other arm is conjectured to extend eastwards below the Gondwana sediments and merge with the Singhbhum shear [8] (Yedekar *et al.*, 1990). The Tan shear [3] is believed to extend below the cover (Yedekar *et al.*, 1990) and possibly joins the Barabhum shear [7] within the Singhbhum block [SB]. Due to the extensive surface cover of the Mahanadi Graben [MG] by the Gondwana sediments, the subsurface extension of these structures needs to be verified. The north-western part of the study region and the northern part of the Godavari Graben are covered by Deccan flood basalts. The Bastar craton consists of two Proterozoic basins (Chattisgarh [C] and Indravati [I]). The Central Indian Tectonic zone (CITZ) (Yedekar *et al.*, 1990) lying to the north of the CIS is marked by several sub-parallel ENE trending faults: Narmada North and South [11 and 12], Tapti fault [1], Gavilgarh fault [2], Tan shear [3], Bamni-Chilpa fault [5] and Tatapani fault [6]. The Tatapani area has several thermal springs that are responsible for the high heat flow in Central India (Ravi Shankar, 1991). The Singhbhum Block [SB] to the east is separated from the rest of the Indian Peninsular Shield by the Mahanadi Graben [MG] occurring to its west and the Sukinda thrust (Mahadevan, 2001) to the south. Tectonically, this block includes the Singhbhum granite (which includes banded iron formation) to the south, and the Proterozoic Singhbhum mobile belt in the middle separated from the Chotanagpur Granite Gneiss terrain in the north by the Barabhum shear [7]. The Eastern Ghat Mobile Belt (EGMB) is a high-grade NE-SW metamorphic belt to the south of the Singhbhum block. The EGMB is separated from the adjoining blocks by a major shear/thrust called Sileru shear zone

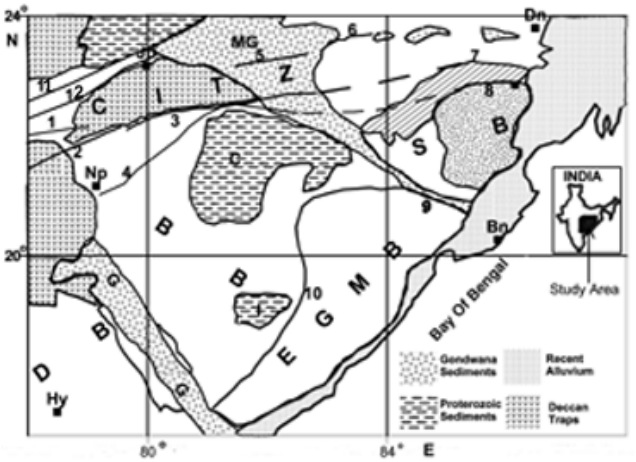


Figure 1 : Simplified geology ande tectonic map of the study area redrawn from Sarkar (2001) and GSI (2000). DB-Dharwar block, BB-Bastar block, SB-Singhbhum block, CITZ-Central Indian Tectonic zone,EGMB-Eastern Ghat Mobile Belt, GG-Godavari graben, MG-Mahanadi graben, I-Indravati basin, C-Chattisgarh basin, 1-Tapti fault, 2-Gavilgarh fault, 3-Tan shear, 4-Central Indian shear, 5-Bamni-Chilpa fault,6-Tatapani fault, 7- arabhum shear, 8-Singhbhum shear, 9-Sukinda thrust, 10-Sileru shear, 11-North Narmada fault, 12-South Narmada fault. Hy-Hyderabad, Bn-Bhubhaneswar, Dn-Dhanbad, Jb-Jabalpur, Np-Nagpur.

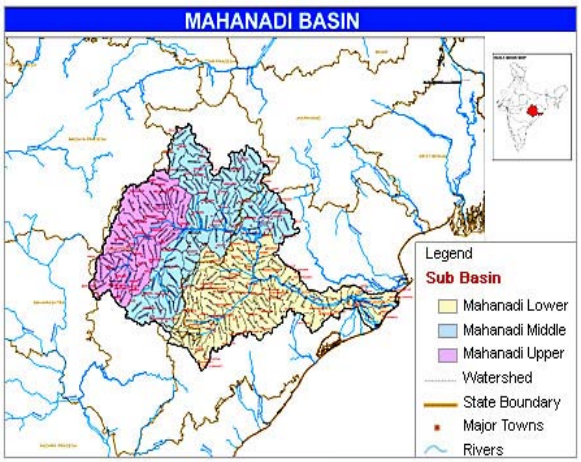


Figure 2 : Figure showing the Mahanadi Basin

Figure 3 : A view of the dam

Since the pseudo-dynamic method does not recognize the oscillatory nature of earthquake loads it is also appropriate to perform the safety evaluation in two phases: (a) the stress analysis using peak spectral acceleration values, and (b) the stability analysis using sustained spectral acceleration values. It is assumed in these analyses that the dynamic amplification applies only to the horizontal rock acceleration. The period of vibration of the dam in the vertical direction is considered sufficiently small to neglect the amplification of vertical ground motions along the height of the dam.

To ensure the accuracy of the pseudo-dynamic method, the structure is divided in thin layers to perform numerical integrations. Number of divisions up to 301 can be specified. The weight of the concrete is 2630Kg/m^3.The Poisson's coefficient was 0.2. The dynamic flexibility of the structure is modeled with the dynamic concrete Young's modulus (Es) 27400MPa. The dam damping on rigid foundation without reservoir interaction is considered to be 0.05. Any change to these basic parameters affects the fundamental period of vibration and the damping of the dam-foundation-reservoir system. Thus the spectral accelerations are evaluated. The wave reflection coefficient (α) is the ratio of the amplitude of the reflected hydrodynamic pressure wave to the amplitude of a vertical propagating pressure wave incident on the reservoir bottom. A value of $\alpha = 1$ indicates that pressure waves are completely reflected, and smaller values of α indicate increasingly absorptive materials .The value of α is considered to be 0.5. The velocity of pressure waves in water is in fact the speed of sound in water. Generally it is assumed at 1440 m/sec (4720 ft/sec).

Because the maximum response in the natural vibration mode and in higher modes doesn't occur at the same time, a modal combination has to be considered. Four options are offered to the user: (i) Only the first mode; (ii) Only the static correction computed for higher modes; (iii) SRSS (square-root-of-the-sum-of-squares of the first mode and static correction for higher modes); or the (iv) Sum of absolute values which provides always conservative results.

The SRSS combination is considered for the study.

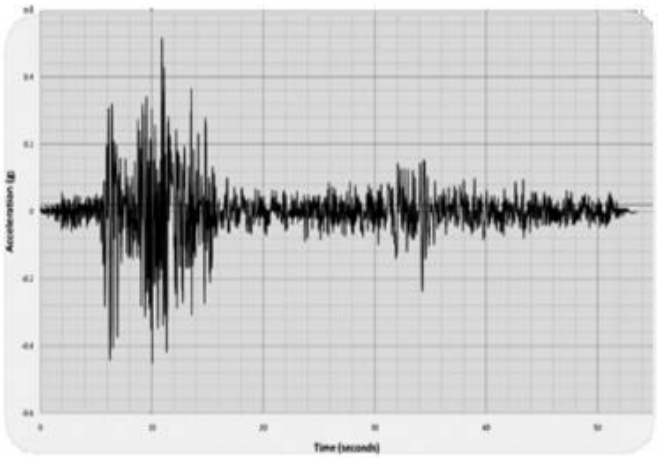


Figure 4 : Accelograph for 12 June 2001 - Konokjora-Sundargarh area, Odisha, Mw 4.7 earthquake

IV. Analysis and Results

Dyamic Analysis of the dam section has been performed using CADAM with the parameters of the dam as input. The dam section has been checked for various load combinations .The result of stress and stability analysis for usual combination had been presented through Table 1 and Table 2 respectively whereas Table 3 and Table 4 depicts the results of stress and stability analysis for flood combination. It is evident from the results that the stress are within the permissible limits on all the joints and the Factor of safety for Overturning and Sliding is quite higher than the desired/safe values as per the code. The results of stress and stability analysis for peak acceleration values and sustained acceleration values for Seismic 1(OBE) has been presented through Table 5-8 It is observed that the dam section is safe for all seismic combinations

and the dam is safe against stresses, sliding and overturning at all the joints considered.

The overall results can be summarized as follows. The dam section is found to be safe for the present PGA values of 0.16g and no further retrofitting measures are required for the section presently. The FOS for sliding and overturning are observed as 8.974 and 6.258 for usual combination where as required is 1.00. For flood combination the FOS is observed as 5.385 and 5.939 whereas required is greater than1. For seismic 1 combination FOS is 19.707 and 4.336 when required is 1.1 . The Static, Pseudo-Static and Pseudo Dynamic Loads with the position of application are summarized from Table 9 to Table 16.

Table 1 : Usual combination (stress analysis)

Joint		Stresses						
ID	Upstream Elevation (m)	Normal stresses U/s (kPa)	D/s (kPa)	Allowable stresses Tension	compression	u/s (kPa)	Shear maximum (kPa)	D/s (kPa)
1	60.000	-23.544	-23.544	0.000	-9990.000			
2	50.000	-299.908	-170.263	0.000	-9990.000			
3	40.000	-565.245	-15.875	0.000	-9990.000	0.000	12.588	12.588
4	30.000	-653.789	-35.684	0.000	-9990.000	0.000	58.710	28.297
5	20.000	-696.683	-114.696	0.000	-9990.000	0.000	121.565	90.951
6	10.000	-717.814	-221.321	0.000	-9990.000	0.000	195.466	175.402
7	Base	-872.986	-342.992	0.000	-9990.000	0.000	280.541	271.984

Table 2 : Usual combination (stability Analysis)

Joint		Safety Factors					Resultants				Uplift
ID	Upstream Elevation	Sliding Peak residual		Overturning Toward u/s	d/s	Uplifting	Normal kN	Shear KN	Moment KN	Position % of joint	Final Force kN
1	60.000	>100	> 100	> 100	> 100	> 100	-215.2	0.0	0.0	50.000	
2	50.000	>100	> 100	> 100	> 100	> 100	-2381.7	0.0	-1108.9	45.404	
3	40.000	>100	40.973	12.909	11.994	12.592	-5247.8	128.1	-4933.7	34.244	50.000
4	30.000	33.034	8.001	5.892	4.876	5.651	-8960.0	1119.9	-34795.1	35.059	45.404
5	20.000	16.566	4.450	4.760	3.403	4.294	-13761.2	3092.7	-55802.8	38.045	34.244
6	10.000	11.085	3.250	4.369	2.779	3.727	-19651.5	6046.5	-72464.9	41.189	35.059
7	Base	8.974	3.032	6.258	3.184	5.101	-30265.7	9981.2	-109446.0	42.736	38.045
Required		>1.00	>1.000	>1.000	>1.000	>1.000					

Table 3 : Flood combination (stress analysis)

joint		Stresses						
ID	Upstream Elevation (m)	Normal stresses U/s (kPa)	D/s (kPa)	Allowable stresses Tension	compression	u/s (kPa)	Shear maximum (kPa)	D/s (kPa)
1	60.000	-23.544	-23.544	0.000	-15000.00			
2	50.000	-191.114	-207.443	0.000	-15000.00	0.000	-22.397	164.497
3	40.000	-293.961	-167.575	0.000	-15000.00	0.000	132.883	132.883
4	30.000	-288.830	-281.060	0.000	-15000.00	0.000	222.874	222.874
5	20.000	-269.627	-422.169	0.000	-15000.00	0.000	334.770	334.770
6	10.000	-247.919	-571.632	0.000	-15000.00	0.000	453.290	453.290
7	Base	-411.487	-724.370	0.000	-15000.00	0.000	574.407	574.407

Table 4 : Flood combination (stability Analysis)

Joint		Safety Factors					Resultants				Uplift
ID	Upstream Elevation	Sliding Peak residual		Overturning toward u/s	d/s	Uplifting	Normal kN	Shear KN	Moment KN	Position % of joint	Final Force kN
1	60.000	> 100	> 100	> 100	> 100	> 100	-215.2	0.0	0.0	50.000	
2	50.000	47.116	7.724	9.462	4.269	6.565	-2018.9	261.4	139.7	50.683	362.8
3	40.000	15.509	2.839	4.707	2.526	3.720	-4167.9	1468.0	-3435.6	45.436	1532.6

4	30.000	9.512	2.026	4.177	2.033	3.128	-7405.9	3655.6	-437.4	49.773	3480.3
5	20.000	7.083	1.719	4.044	1.819	2.891	-11733.0	6824.3	14626.2	53.675	6206.0
6	10.000	5.782	1.563	3.998	1.702	2.766	-17149.2	10973.9	47247.1	56.583	9709.5
7	Base	5.385	1.755	5.939	2.033	4.016	-28271.5	16104.5	64611.4	54.591	9374.0
Required		>1.0000	>1.000	>1.000	>1.000	>1.000					

Table 5 : Seismic #1 combination-Peak accelerations (Stress Analysis)

joint		Stresses						
ID	Upstream Elevation (m)	Normal stresses U/s (kPa)	D/s (kPa)	Allowable stresses Tension	compression	Shear u/s (kPa)	D/s (kPa)	maximum (kPa)
1	60.000	-28.061	-24.050	0.000	-27270.000	0.000	-9.068	0.000
2	50.000	-485.349	-34.973	0.000	-27270.000	0.000	-68.147	27.733
3	40.000	-797.246	0.000	0.000	-27270.000	0.000	-45.624	0.000
4	30.000	-841.444	0.000	0.000	-27270.000	0.000	26.446	0.000
5	20.000	-878.089	-46.114	0.000	-27270.000	0.000	63.312	36.567
6	10.000	-960.965	-115.083	0.000	-27270.000	0.000	98.155	91.258
7	BASE	-1204.610	-172.699	0.000	-27270.000	0.000	138.375	136.946

Table 6 : Seismic #1 combination-Peak accelerations (Stability Analysis)

Joint		Safety Factors					Resultants				Uplift
ID	Upstream Elevation	Sliding Peak	residual	Overturning Toward u/s	d/s	Uplifting	Normal kN	Shear KN	Moment KN	Position % of joint	Final Force kN
1	60.000	> 100	4.310	38.973	> 100	> 100	-238.1	-55.3	-27.9	48.717	
2	50.000	32.229	6.437	4.619	> 100	> 100	-2635.7	-409.5	-3852.3	35.574	48.6
3	40.000	63.373	13.106	3.801	14.598	13.936	-5855.8	-446.8	-14337.2	27.112	452.7
4	30.000	95.377	23.863	3.999	5.662	6.254	-10121.2	424.1	-40580.1	30.853	1926.3
5	20.000	33.843	9.830	4.103	3.872	4.752	-15674.7	1594.6	-79772.5	34.997	4177.8
6	10.000	23.665	7.492	3.656	3.187	4.124	-22516.4	3005.3	-123459.6	36.898	7207.2
	Base	19.707	7.089	4.336	3.700	5.645	-34281.2	4835.9	-213093.8	37.513	7379.7
Required		>1.000	>1.000	>1.00	>1.00	>1.00					

Table 7 : Seismic #1 combination-Sustained accelerations (Stress Analysis)

joint		Stresses						
ID	Upstream Elevation (m)	Normal stresses U/s (kPa)	D/s (kPa)	Allowable stresses Tension	compression	u/s (kPa)	Shear maximum (kPa)	D/s (kPa)
1	60.000	-25.491	-23.167	0.000	-27270.000	0.000	-5.267	0.000
2	50.000	-405.094	-80.749	0.000	-27270.000	0.000	-58.450	64.032
3	40.000	-694.229	0.000	0.000	-27270.000	0.000	-32.352	0.000
4	30.000	-781.563	0.000	0.000	-27270.000	0.000	27.458	0.000
5	20.000	-824.091	-22.546	0.000	-27270.000	0.000	90.646	17.878
6	10.000	-854.207	-127.713	0.000	-27270.000	0.000	150.389	101.273
7	Base	-1026.093	-240.301	0.000	-27270.000	0.000	218.551	190.553

Table 8 : Seismic #1 combination-Sustained accelerations (Stability Analysis)

Joint		Safety Factors					Resultants				Uplift
ID	Upstream Elevation	Sliding Peak	residual	Overturning toward u/s	d/s	Uplifting	Normal kN	Shear KN	Moment KN	Position % of joint	Final Force kN
1	60.000	> 100	6.929	62.817	> 100	> 100	-222.4	-32.1	-16.2	49.204	
2	50.000	48.511	9.221	6.952	> 100	> 100	-2461.1	-266.9	-2774.3	38.873	
3	40.000	79.350	16.094	4.571	13.316	13.012	-5437.8	-337.9	-14197.9	28.913	452.7
4	30.000	90.446	21.348	3.717	5.310	5.840	-9322.8	436.7	-37068.9	30.597	1926.3

5	20.000	24.279	6.693	3.573	3.662	4.437	-14359.2	2145.4	-76854.7	34.221	4177.8
6	10.000	14.504	4.363	3.537	2.972	3.851	-20546.8	4709.6	-106034.4	37.669	7207.2
7	Base	11.298	3.898	4.781	3.397	5.271	-31520.5	8086.4	-162269.2	39.658	7379.7
Required		>1.000	>1.000	>1. 00	>1.00	>1.00					

Table 9 : Static Loads (1/1)

Joint		Self Weight Dam		Normal Operating Level Upstream Reservoir		Uplift	
ID	Upstream Elevation	Vertical Load		Horizontal Load		Normal Load	
		D(kN)	Position x	Hnu(kN)	Elevation(m)	Un(kN)	Position l(m)
1	60.00	-215.2	4.570				
2	50.00	-2381.7	4.600				
3	40.00	-5700.5	6.133	128.1	41.703	452.7	6.020
4	30.00	-10886.3	6.515	1119.9	35.037	1926.3	8.664
5	20.00	-17939.0	11.090	3092.7	28.370	4177.8	11.307
6	10.00	-26858.7	13.721	6046.5	21.703	7207.2	13.950
7	Base	-37645.4	16.370	9981.2	15.037	7379.7	16.593

Table 10 : Static Loads (2/2)

Joint		Flood Level Upstream Reservoir		Uplift	
ID	Upstream Elevation	Horizontal Load		Normal Load	
		Hnu(kN)	Elevation(m)	Un(kN)	Position l(m)
1	60.00				
2	50.00	261.4	52.433	362.8	3.377
3	40.00	1468.0	45.767	1532.6	6.020
4	30.00	3655.6	39.100	3480.3	8.664
5	20.00	6824.3	32.433	6206.0	11.307
6	10.00	10973.9	25.767	9709.5	13.950
7	Base	16104.5	19.100	9374.0	16.593

Table 11 : Pseudo-Static Loads (Seismic Coefficient)-Stress Analysis

JOINT		Inertia Load Dam				Reservoirs (Operating Level) Upstream	
ID	Upstream Elevation	Horizontal Load		Vertical Load		Horizontal Load	
		Qh (Kn)	Elevation (m)	Qv (kN)	Position x(m)	Hdu (kN)	Elevation (m)
1	60.00	-34.4	60.500	-23.0	4.570		
2	50.00	-381.1	55.469	-254.0	4.600		
3	40.00	-912.1	49.101	-608.1	6.133	-66.1	42.044
4	30.00	-1741.8	42.241	-1161.2	8.515	-336.2	36.044
5	20.00	-2870.2	35.376	-1913.5	11.090	-720.3	30.044
6	10.00	-4297.4	28.551	-2864.9	13.721	-1190.9	24.044
7	Base	-6023.3	21.762	-4015.5	16.370	-1734.3	18.044

Table 12 : Pseudo-Static Loads (Seismic Coefficient)

JOINT		Inertia Load Dam				Reservoirs (Operating Level) Upstream	
ID	Upstream Elevation	Horizontal Load		Vertical Load		Horizontal Load	
		Qh (Kn)	Elevation (m)	Qv (kN)	Position x(m)	Hdu (kN)	Elevation (m)
1	60.00	-10.8	60.500	-7.2	4.570		
2	50.00	-119.1	55.469	-79.4	4.600		

Table 13 : Pseudo - Dynamic Loads (Chopra' S Method) - Stress Analysis (1 / 2)

JOINT		FIRST MODE						HIGHER MODES						MODAL COMBINATION	
		DAM		RESERVOIR (UPSTREAM)		TOTAL		DAM		RESERVOIR (UPSTREAM)		TOTAL		SRSS	
		HORIZONTAL LOAD		HORIZONTAL LOAD		HORIZONTAL LOAD		HORIZONTAL LOAD		HORIZONTAL LOAD		HORIZONTAL LOAD		HORIZONTAL LOAD	
ID	Upstream Elevation (m)	Eq1 (kN)	elevation (m)	Hd1 (kN)	elevation (m)	Em1 (kN)	Elevation (m)	Eqs (kN)	Elevation (m)	Hds (kN)	Elevation (m)	Ems (kN)	Elevation (m)	Emc (kN)	Elevation (m)
1	60.00	-28.5	60.504			-28.5	60.504	47.3	60.506			47.3	60.506	-55.3	60.505
2	50.00	-246.6	56.009			-246.6	56.009	326.9	56.639			326.9	56.639	-409.5	56.411
3	40.00	-440.1	51.142	-12.5	41.880	-452.6	50.886	351.6	56.437	2.9	56.776	354.5	56.439	-574.9	53.066
4	30.00	-620.8	46.491	-61.0	36.260	-681.8	45.576	40.8	227.787	-179.4	33.763	-138.6	-23.386	-695.7	44.904
5	20.000	-754.2	42.751	-112.7	31.111	-866.9	41.238	-704.6	12.705	-517.2	27.833	-1221.8	19.109	-1498.1	28.502
6	10.000	-830.4	40.261	-159.3	26.432	-989.7	38.035	-1912.9	13.955	-962.7	21.822	-2875.6	16.589	-3041.2	19.981
7	Base	-855.0	39.293	-200.3	22.070	-1055.4	36.024	-3568.0	9.698	-1468.0	16.008	-5035.9	11.537	-5145.3	13.495

3	40.00	-285.0	49.101	-190.0	6.133		-20.7	42.044	-542.0	-372.2	-225.1	30.044	24.044	18.044	
4	30.00	-544.3	42.241	-362.9	8.515	-105.1	36.044								
5	20.00	-897.0	35.376	-598.0	11.090	-225.1	30.044								
6	10.00	-1342.9	28.551	-895.3	13.721	-372.2	24.044								
7	Base	-1882.3	21.762	-1254.8	16.370	-542.0	18.044								

Table 14 : Pseudo - Dynamic Loads (Chopra' S Method) - Stress Analysis (2 / 2)

JOINT		VERTICAL LOADS	
		DAM	
		VERTICAL LOAD	
ID	Upstream Elevation (m)	Eqv (kN)	Position x (m)
1	60.000	-28.5	60.504
2	50.000	-246.6	56.009
3	40.000	-440.1	51.142
4	30.000	-620.8	46.491
5	20.000	-754.2	42.751
6	10.000	-830.4	40.261
7	Base	-855.0	39.293

Table 15 : Pseudo -Dynamic Loads (Chopra' S Method) - Stability Analysis (1 / 2)

JOINT		FIRST MODE						HIGHER MODES						MODAL COMBINATION	
		DAM		RESERVOIR (UPSTREAM)		TOTAL		DAM		RESERVOIR (UPSTREAM)		TOTAL		SRSS	
		HORIZONTAL LOAD		HORIZONTAL LOAD		HORIZONTAL LOAD		HORIZONTAL LOAD		HORIZONTAL LOAD		HORIZONTAL LOAD		HORIZONTAL LOAD	
ID	Upstream Elevation (m)	Eq1 (kN)	elevation (m)	Hd1 (kN)	elevation (m)	Em1 (kN)	Elevation (m)	Eqs (kN)	Elevation (m)	Hds (kN)	Elevation (m)	Ems (kN)	Elevation (m)	Emc (kN)	Elevation (m)
1	60.000	-28.5	60.504			-28.5	60.504	14.8	60.506			14.8	60.506	-32.1	60.504
2	50.000	-246.6	56.009			-246.6	56.009	102.2	56.639			102.2	56.639	-266.9	56.101
3	40.000	-440.1	51.142	-12.5	41.880	-452.6	50.886	109.9	56.437	0.9	56.776	110.8	56.439	-466.0	51.216
4	30.000	-620.8	46.491	-61.0	36.260	-681.8	45.576	12.8	227.787	-56.1	33.763	-43.3	-23.386	-683.2	45.508
5	20.000	-754.2	42.751	-112.7	31.111	-866.9	41.238	-220.2	12.705	-161.6	27.833	-381.8	19.109	-947.3	38.518
6	10.000	-830.4	40.261	-159.3	26.432	-989.7	38.035	-597.8	13.955	-300.8	21.822	-898.6	16.589	1336.8	30.287
7	Base	-855.0	39.293	-200.3	22.070	-1055.4	36.024	-1115.0	9.698	-458.7	16.008	-1573.7	11.537	1894.8	22.235

Table16 : PSEUDO - DYNAMIC LOADS (CHOPRA' S METHOD) - STABILITY ANALYSIS (2/ 2)

		DAM	
		VERTICAL LOAD	
ID	Upstream Elevation (m)	Eqv (kN)	Position x (m)
1	60.000	-7.2	4.570
2	50.000	-79.4	4.600
3	40.000	-190.0	6.133
4	30.000	-362.9	8.515
5	20.000	-598.0	11.090
6	10.000	-895.3	13.721
7	Base	-1254.8	16.370

V. Conclusions and Recommendations

Results presented in this paper demonstrate that the response of concrete gravity dam-reservoir systems is significantly affected by various static and dynamic loading parameters. The design check of existing dam is performed, for the present PGA value of the earlier earthquake i.e. 0.16g, to assess whether seismic upgrading of Hirakud Dam is necessary from seismic safety point of view. It can be concluded from the present study that the dam section is safe for all possible load combinations and no further retrofitting measures are required for the section.

References Références Referencias

1. Anatech Corporation" ANACAP-Concrete Analysis Program", Version 2.le, 1997.
2. Bureau of Reclamation (1976)."Design of Gravity dams" A Water Resources Technical Publication.
3. Chopra A.K. *Dynamics of Structures – Theory and Application to Earthquake Engineering*. Prentice Hall, 2001.
4. Chopra A.K. and Hanchen T.,"EACD-3D-96: A Computer program for 3-dimensional analysis of concrete Dam" University of California, Berkeley, California, Report No.UCB/SEMM-96/06,October 1996.
5. Fenves and Chopra A.K. (1987)"Simplified Analysis of Concrete Dams", Journal of Structural Engineering, ASCE, Vol.113, No.8, pp1688-1708.
6. FERC (Federal Energy Regulatory Commission). Chapter III Gravity Dams. In: Federal Energy Regulatory Commission, Office of Hydropower Licensing. Engineering guidelines for evaluation of hydropower projects. Washington, 2002.
7. Gupta I.D. (2002)"The state of the art in Seismic Hazard Analysis", ISET Journal of Earthquake Technology, Paper No.428, Vol.39, No.4, December 2002, pp 311-346.
8. ICOLD (1989) 'Selecting Parameters for Large dams-Guidelines and Recommendations' ICOLD Committee on Seismic Aspects of Large dams, Bulletin 72.
9. Koltuniuk, R.M., HVD-8110-MDA-97-4,"Non-linear Dynamic Structural Analysis of Hoover Dam Including Modelling of Contraction Joint Opening and Concrete Cracking ", Bureau of Reclamation, September 1997.
10. Kramer, Steven L.1996, Geotechnical Earthquake Engineering, Prentice Hall, 653 pp.
11. Krinitzsky, E. L. (1995), Deterministic versus probabilistic seismic hazard analysis for critical structures, Eng Geol 40, 1–7.
12. Mills,B.L.,HVD-8110-MDA-97-5,"Kinematic studies to determine the stability of postulated independent concrete blocks indicated by the non-linear analysis of Hoover Dam during Seismic Loading", Bureau of Reclamation, December 1997.
13. National Research Council (NRC) 1985, Safety of Dams; Flood and Earthquake Criteria, Washington D.C; National Academy Press.
14. O'Connell, D. and Ake, J.,"Ground Motion Analysis for Hoover dam", Bureau of Reclamation, Seismotectonic Report 94-1, January 1995.
15. Payne, T.L.HVD-8110-MDA-97-2,"Linear Elastic Dynamic Structural Analysis including mass in the foundation for Hoover Dam", Bureau of Reclamation, April, 1998.
16. Sahu, Tejram 2006-07, NIT, Raipur, Chhattisgarh, "Seismic Hazard Analysis of Gangrel and Sondur Dam Sites", M.Tech.desertation.
17. Sarma S. K. (1975), Seismic stability of earth dams and embankments. Geotechnique, 25, 743 - 761, ISSN: 0016-8505.
18. Scott, G."RIGID-Dynamic Response of Jointed Rock Masses", University of Colorado, 1982.
19. United States Committee on Large Dams,"U.S. and World Dam, Hydropower and Reservoir Statistics", USCOLD Committee on Register of Dams, 1995.
20. USBR, *Design of Gravity Dams*. Denver: United States Department of the Interior – Bureau of Reclamation, 1976.
21. Westergaard H. M., "Water pressure on dams during earthquakes" *Transactions ASCE*, v. 98, n. 1835, pp. 418-433, 1933.

Global Journal of Researches in Engineering
Civil And Structural Engineering
Volume 13 Issue 1 Version 1.0 Year 2013
Type: Double Blind Peer Reviewed International Research Journal
Publisher: Global Journals Inc. (USA)
Online ISSN: 2249-4596 & Print ISSN: 0975-5861

Effect of Alkali Content on Strength and Microstructure of GGBFS Paste

By Mohd. Nadeem Qureshi & Somnath Ghosh
Jadavpur University, Kolkata, India

Abstract - The effect of alkali content (% K2O + %Na2O) on the mechanical properties of alkali activated blast furnace paste has been investigated. The paper presents the study on workability, compressive strength, split tensile strength and microstructure of alkali activated blast furnace slag paste specimens prepared by using of sodium silicate and potassium hydroxide solution as activators. The experimental results have indicated that the compressive strength, split tensile strength and workability of the specimens is significantly affected by the alkali content of the mix. The highest compressive strength achieved was 51.44 MPa. The mineralogical and micro structural changes were studied using XRD and scanning electron microscopy (SEM).

Keywords : alkali activated blast furnace slag, K2O content, compressive strength, XRD, microstructure.

GJRE Classification : FOR Code : 090599

Strictly as per the compliance and regulations of :

Effect of Alkali Content on Strength and Microstructure of GGBFS Paste

Mohd. Nadeem Qureshi [α] & Somnath Ghosh [σ]

Abstract - The effect of alkali content (% K_2O + %Na_2O) on the mechanical properties of alkali activated blast furnace paste has been investigated. The paper presents the study on workability, compressive strength, split tensile strength and microstructure of alkali activated blast furnace slag paste specimens prepared by using of sodium silicate and potassium hydroxide solution as activators. The experimental results have indicated that the compressive strength, split tensile strength and workability of the specimens is significantly affected by the alkali content of the mix. The highest compressive strength achieved was 51.44 MPa. The mineralogical and micro structural changes were studied using XRD and scanning electron microscopy (SEM).

Keywords : alkali activated blast furnace slag, K_2O content, compressive strength, XRD, microstructure.

I. Introduction

Ground granulated blast furnace slag 'GGBFS' is one of the 'greenest' of construction materials. It is a by-product from the blast-furnaces manufacturing iron. By comparison with Portland cement, manufacture of alkali activated blast furnace slag (AABFS) paste requires less than a fifth of energy and can save up to 80% of CO_2 emission caused by the cement industries. Each year, India produced up to eleven million tonnes of GGBFS which can be significantly utilized in manufacturing of construction material which is environment- friendly and will greatly reduce primary energy, saves bulk of quarrying as well as potential landfill. Blast furnace slag consists primarily of silicates, alumina-silicates and calcium-alumina-silicates and can be good raw material for making high materials which can be utilized in various civil engineering applications.

Blast furnace slag as a byproduct have a different composition depending on the raw materials and the industrial processes; hence, each slag differs in response to activation (Wang et al, 1994; Bakhrev et al, 1999). The optimum slag composition for blast furnace operation falls in CaO-MgO- Al_2O_3-SiO_2 system (Osbom et al, 1954). Many researchers have confirmed that water-glass is a very effective activator (Glukhovsky et al, 1978; Shi et al, 1989a; Shi et al, 1989 b). Many results confirmed that the effect, that an activator has on strength development may be different for slag of different origins. The results on activation of Australian slag by a combination of NaOH and Na_2CO_3 were published elsewhere.(Collins and Sanjayan,1998).

Alkali activated blast furnace slag paste behaves differently than OPC. There is insufficient knowledge about the relationship between alkali activated slag properties and synthesizing parameters of alkali activation. The present study was conducted to study the effects of alkali contents (% K_2O+ % Na_2O) on compressive strength on alkali activated blast furnace slag paste. The mineralogical and microstructure changes were studied using XRD and scanning electron microscopy.

II. Experimental Investigation

a) Materials

i. Slag

Ground granulated blast furnace slag used in this investigation obtained from the Tata Metalliks Ltd. Kharagpur, India. The chemical composition is given in Table 1. Its density was 2900 kg/m^3. Slag was ground to the particle size 100% passing 45 micron sieve. The moisture content was less than 1%. Based on the chemical composition, blast furnace slag is classified as an acidic with the basicity coefficient Kb = (CaO + MgO+Fe_2O_3)/(SiO_2+Al_2O_3) = 0.82 and the hydration modulus = (CaO + MgO + Al_2O_3)/SiO_2 =1.84. It consists of 85% glass and having some crystalline components such as akermanite, gehlenite, quartz etc.

ii. Alkaline Activator

The alkaline activator liquid was the combination of sodium silicate and potassium hydroxide pellets. Laboratory grade potassium hydroxide was supplied by Merck India Ltd. (84% purity with K_2O =83.93% and 16.07% water) and sodium silicate solution (Na_2O=8%, SiO_2=26.5% and 65.50% water) with silicate modulus ~3.3 and bulk density of 1410 kg/m^3 was supplied by Loba Chemie Ltd. India, were used to adjust the desired composition of AABFS.

Author α : M.E.(Struct.), MBA, C.Eng. Research Scholar, Department of Civil Engineering, Jadavpur University, Kolkata, India. (Senior Lecturer, Govt. Polytechnic, Khamgaon).
Author σ : Ph.D., Professor, Department of Civil Engineering, Jadavpur University, Kolkata, India.

Table 1 : Chemical composition of blast furnace slag by XRF

Chemical composition	SiO_2	CaO	Al_2O_3	MgO	Fe_2O_3	S	MnO	LOI*
Mass (%)	32.5	33.5	18.5	8.00	0.40	0.5	0.55	0.7

* Loss on ignition

b) Test methods and preparation of test specimens

i. *Compressive strength and split tensile strength*

The alkali activated GGBFS paste specimens (50mm x 50mm x 50mm) were tested for compressive strength using 20 ton capacity digital compressive testing machine with a loading rate of 20 MPa/min. The compressive strength tests were conducted at the age of 3, 7 and 28 days. Three specimens of each series at each age were crushed in a digital compression testing machine in accordance with ASTM C-109-02 and the average strength of three specimens is reported as the compressive strength. The split tensile strength at the age of 28 days was tested in accordance to ASTM C-496, using 50 mm diameter by 100 mm long cylinders.

ii. *Workability*

The workability was assessed using mini flow table test as per ASTM C 1437-07 with a modification; the table was raised and dropped 15 times in about 15 seconds. The mini flow table apparatus was used as per ASTM C 230/C 230M. The workability of the mix was determined by measuring the diameter of paste flow on a flow table in two perpendicular directions after 15 drops in 15 seconds and the average value is considered as a flow diameter. The percentage increase in flow diameter with respect to the initial diameter of mould is considered as flow value.

iii. *XRD and SEM/EDAX*

To perform the XRD analysis, paste sample was carefully removed from the core of the sample to be tested. Each sample was finely ground (passing 45 microns) and then analysed using XRD. The mineralogical phases present in the specimens were monitored by means of X-ray diffraction (XRD) using a Rigaku Miniflex XRD machine with Cu-Kα radiation in steps of 0.5^0 (2theta) at a rate of 1^0 (2 theta) per minute, sweep from 10^0 to 90^0 (2 theta), according to the diffraction powder method. The results were compared with the International Centre for Diffraction Data (ICDD) database.

Scanning Electron Microscopy (SEM) was used to record micrographs while energy dispersive x-ray spectroscopy (EDAX) was used for semi - quantitative analysis. A JEOL JSM 6360 equipped with an Inca Oxford EDX analyzer was used for obtaining SEM micrographs and EDAX spectra of raw slag and alkali activated blast furnace slag specimens.

iv. *Preparation of alkali activated paste*

The alkali activated blast furnace slag (AABFS) paste was prepared by varying % K_2O ratio from 4 to 10 % by keeping constant percentage of SiO_2 = 8 %. The compositional change in AABFS mix was obtained by adjusting the quantity of potassium hydroxide (KOH), sodium silicate solution and water. The activator solution was prepared at least one day prior to casting of test specimens. The water / slag ratio was kept constant equal to 0.32. The chemical composition of AABFS mix and corresponding compressive strength of specimens are presented in Table 2.

For making AABFS paste specimens, the blast furnace slag and activating solution in desired proportion was first mixed together for five minutes in a Hobart Mixer to get homogeneous paste. The fresh paste mix had a sticky nature with good workability. The fresh mix was then transferred into 50 mm ×50 mm ×50 mm steel moulds and vibrated for two minutes on vibrating table to remove any entrapped air. The specimens were left at room temperature for 24 hours, then demoulded and kept in water in fully immersed condition at room temperature until testing was done. The tests were conducted at the age of 3, 7 and 28 days.

Table 2 : Detail of mix composition of alkali activated blast furnace slag paste

Mix ID	Mix Composition							
	% K_2O	%Na_2O	%SiO_2	SiO_2/(K_2O+Na_2O)	w/b	w/s	H_2O/K_2O	Slag/ alkaline activator
AABFS4-8	4	2.41	8	1.24	0.297	0.32	8.5	2.79
AABFS6-8	6	2.41	8	0.95	0.283	0.32	5.5	2.58
AABFS8-8	8	2.41	8	0.76	0.279	0.32	4.13	2.41
AABFS10-8	10	2.41	8	0.64	0.274	0.32	3.3	2.25

- % of mass added with respect to the total mass of slag
- Binder = mass of (Slag + K_2O+Na_2O+ SiO_2)

III. Results and Discussion

a) Workability

Fig.1 presents the effect of alkali content on the workability of blast furnace slag paste. The alkali content (% K_2O) was varied from 4% to 10% by weight of slag while keeping silica content and water to slag ratio of the mix constant at 8% and 0.32 respectively. The minimum and maximum flow (%) of 41 % and 74.5% was observed for alkali content of 4% and 10% respectively. It can be noticed that, % flow increased linearly with increase in % K_2O. The percentage increase in flow was observed to be 14%, 24% and 33.5% with an increase in alkali content from 6% to 10% respectively. The alkali activated blast furnace slag paste mix AABFS4-8 was very stiff while AABFS10-8 showed high workability. Increasing the alkali content decreases viscosity of mix resulting in an increase in flow. As the % K_2O values increased (greater KOH concentration), the amounts of water (w/b and H_2O/K_2O) necessary to ensure the pastes to reach normal consistency decreases, hence causing greater slag grain particles solubilization, which enabled greater formation of C-S-H gel, which is responsible for greater workability of fresh paste samples and for mechanical strength when the material is hardened.

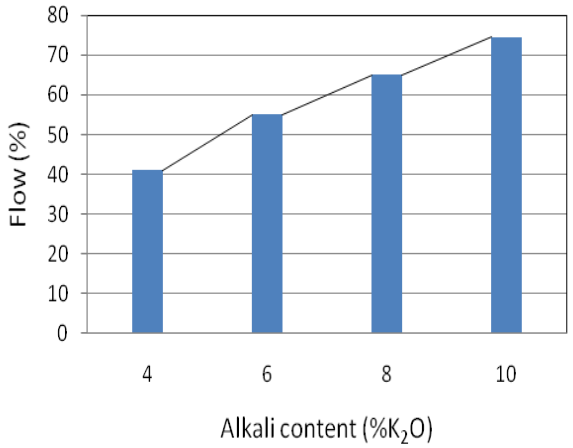


Figure 1 : Effect of alkali content (% K_2O) on flow (%) of AABFS paste

b) Dir ect compressive strength

Table 2 presents synthesis parameters and the compressive strength of AABFS paste specimens produced at alkali content (% K_2O) varied from 4% to 10%. Water to slag ratio and silica content was kept constant to 0.32 and 8 % respectively. Fig.2 shows the compressive strength of paste specimen at the age of 3, 7 and 28 days. As shown in Fig.2, compressive strength increases with increase in alkali content from 4% K_2O to 8 % K_2O and reaches maximum 51.44 MPa for alkali content of 8% . This increase in compressive strength may be due to increase in cations from potassium hydroxide which provide charge balance and anions in sodium silicate reacts with Ca^{2+} dissolving from the surface of the slag grains and forms the primary C-S-H (Shi and Li, 1989). Further increase in alkali content reduces the compressive strength of 45.82 MPa for alkali content (% K_2O) of 10%. Due to further increase in alkali content, all the slag particles might not be completely utilized for the production of C-H-S gel and degree of reaction of the system might reduce. The minimum compressive strength of 42.80 MPa the age of 28 days was observed in 4% K_2O. Fig. 3 presents strength development of AABFS paste with an age. The percentage increase in 28 days compressive strength over 7 days compressive strength after water curing was 40.23, 27.6%, 26.69% and 26.57% for alkali content of 4%, 6%, 8% and 10% respectively. The high early strength of 30.7 MPa and 24.45 MPa at 3 days curing time was observed in the specimens having 8% and 10 % K_2O content, indicating higher percentage of potassium hydroxide increases the early strength of AABFS paste. This may be due to the strong alkaline environment, higher OH^- concentration to overcome the – O –Si – O- Al – O- chain decomposition activation energy, making the phase of calcium rich to hydrate rapidly, thus showing a rapid increase of strength of slag. Many studies have confirmed that the modulus of the water glass has a significant effect on the properties of alkali activated slag cements. 10.92% reduction in 28 days compressive strength was observed to increase in alkali content from 8% to 10%, probably due to excess K^+ ions in the framework, the slag grains might not

C-S-H gel and the degree of reaction of the system might remain moderate. In the present study, the optimum silicate modulus SiO_2 /(K_2O+Na_2O) ratio of this type of slag is around 0.8 (Fig.4). The optimum silicate modulus phenomenon to the formation of "primary C-S-H" and /or polymerization of silicate anions in the water glass, which promotes the hydration of slag and the formation of less porous structure (Shi et al, 1989). The alkali metal cations in the original materials or added alkali metal hydroxides are considered important due to their catalytic role.

Table 3 : Workability, Compressive strength and Split tensile strength of AABFS paste

Mix ID	Workability (Flow %)	Compressive Strength (MPa)			Split tensile strength (MPa)
		3 days	7 days	28 days	28 days
AABFS4-8	41	18.38	30.52	42.8	4.52
AABFS6-8	55	26.60	37.6	48	5.1
AABFS8-8	65	30.7	40.6	51.44	5.81
AABFS10-8	74.5	24.45	36.2	45.82	4.76

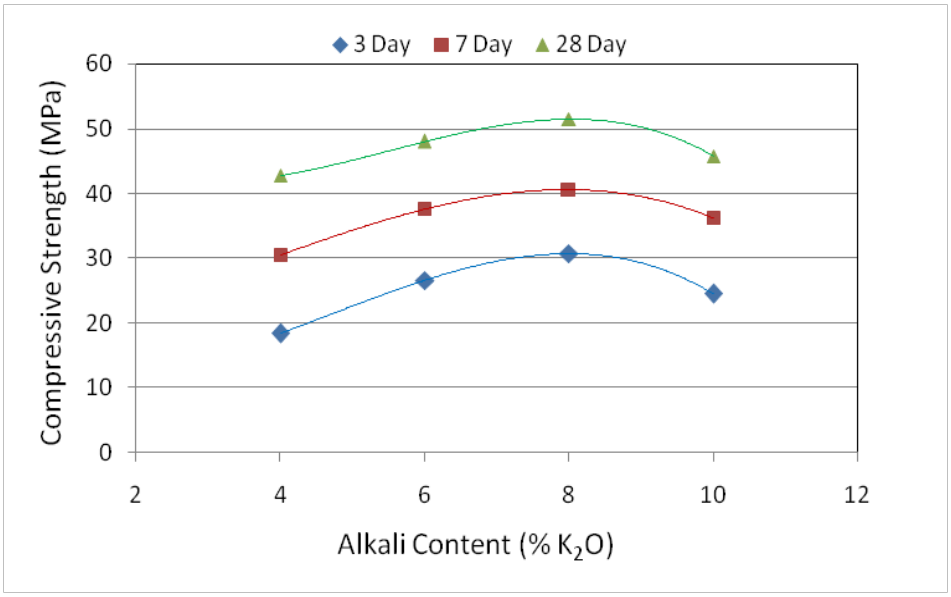


Figure 2 : Compressive strength development with an age of various alkali content

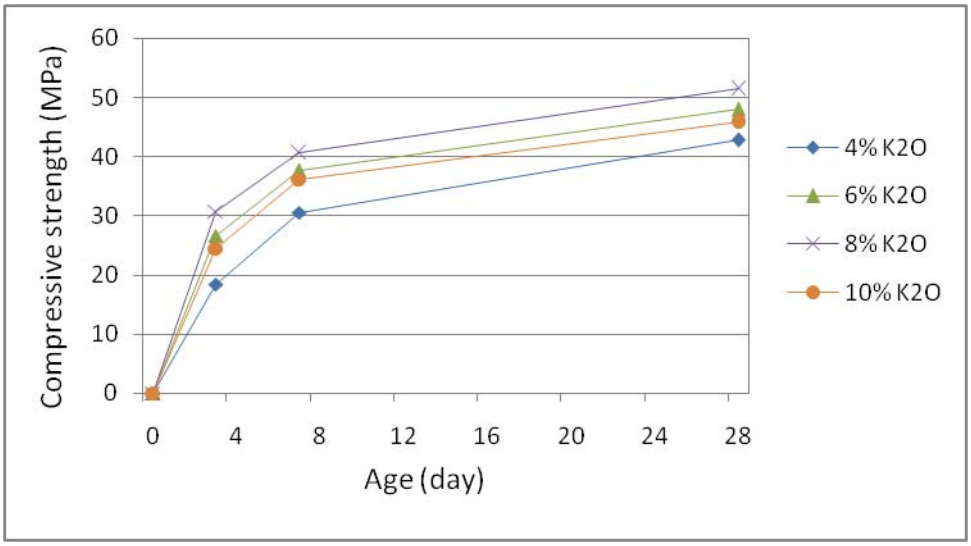


Figure 3 : Compressive strength development of alkali activated blast furnace slag paste with an age (8% SiO_2)

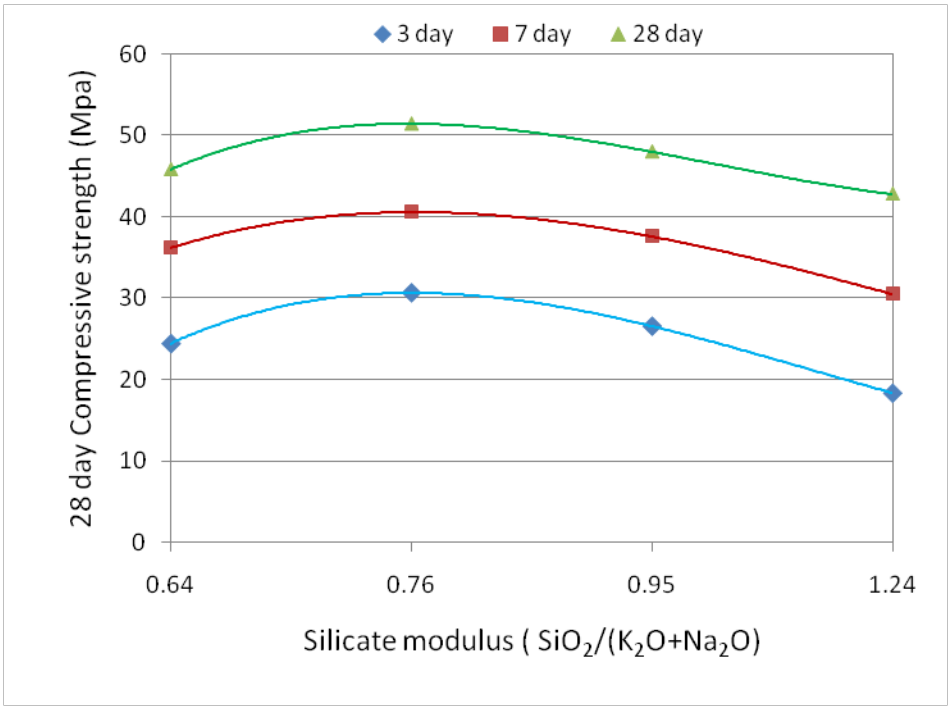


Figure 4 : Effect of silicate modulus - $SiO_2/(K_2O + Na_2O)$ on 28-day compressive strength of AABFS paste

c) Effect of alkali content on split tensile strength of AABFS paste

Fig. 5 shows the relationship between alkali content and split tensile strength. AABFS paste specimens produced with alkali content (% K_2O) varied from 4 % to 10%. Water to slag ratio and silicate content was kept constant to 0.32 and 8% respectively. In Fig. 5, it was observed that split tensile strength increases with increase in alkali content until 8% K_2O content, thereafter there is a decrease in split tensile strength for 10% K_2O content. The maximum and minimum split tensile strength of 5.81 MPa and 4.52 MPa was observed in 8% and 4% K_2O content.

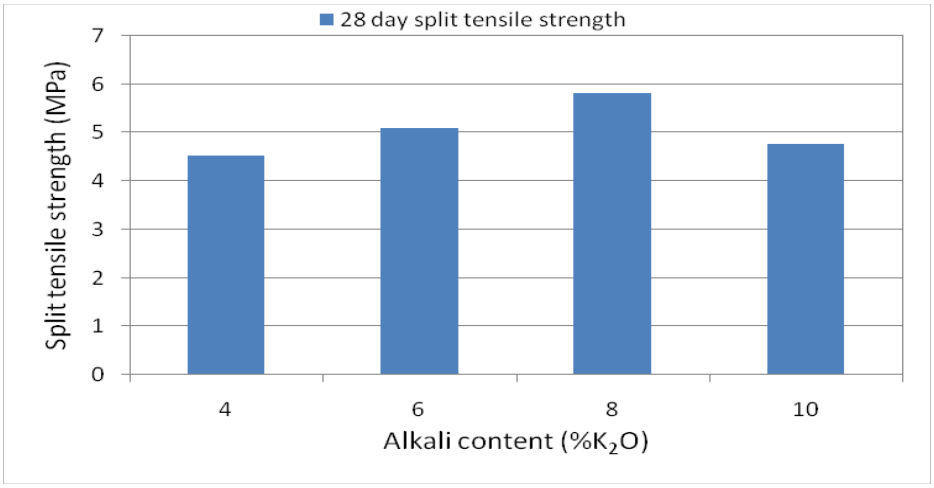


Figure 5 : 28 day split tensile strength of the AABFS paste with various alkali contents

d) Mineralogical Investigation by XRD

The alkali activated specimens that produced the best results for compressive strength is considered for XRD analysis. Fig.6 shows an X-ray diffraction pattern of untreated blast furnace slag and alkali activated blast furnace slag with various alkali contents (% K_2O). GGBFS was predominantly amorphous with small amount of crystalline phases such as akermanite, gehlenite and quartz. Comparing the XRD spectra of the original raw slag with those of hardened alkali activated slag paste specimen, the AABFS paste specimen is mainly amorphous in view of the large diffuse diffraction peak at about 20 - 40 (2θmax Cu K) . In addition, several sharp characteristic peaks are also seen from Fig.6. The alkaline cations act as a destruction catalyst, based on the wave character of activated slag cement, during the destruction of the glassy slag structure and formation of hydrates [Krivenko, 1992]. The XRD patterns of alkali activated specimens show the formation of amorphous C-S-H gel that has resulted in a decrease in porosity and higher compressive strength. X-ray diffraction studies of alkali activated slag paste proved that calcium silicate hydrates (C-S-H) are the main phase having noticeable amorphous character.

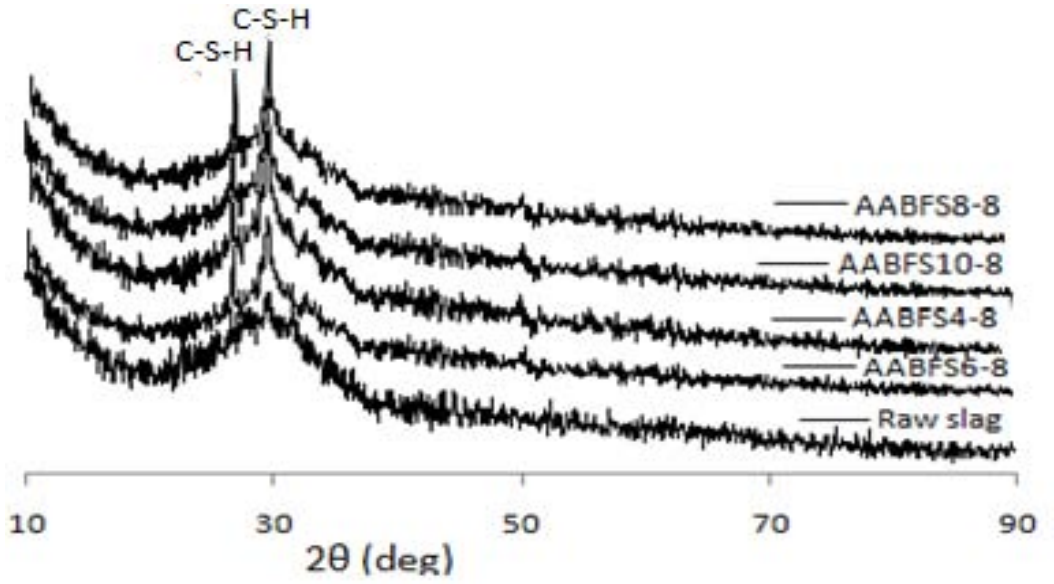


Figure 6 : XRD patterns of alkali activated blast furnace slag paste at curing time of 28 days

e) Microstructure study by scanning electron microscopy (SEM) and energy dispersive spectroscopy (EDAX)

Samples for Microstructure of AABFS hardened specimen was investigated using scanning electron microscopy, which is reflected in Fig.7. Alkali activated specimens with the highest compressive strength of all systems which were studied at the age of 28 days were considered for SEM and EDAX. The micrographs were taken with the objective of analyzing their micro structural evolution. Table 4 shows elemental analysis of raw slag and alkali activated blast furnace slag paste determined by EDAX. The Ca/Si, Ca/Si and Si/Al ratio of raw slag was 1.08, 1.63 and 1.5 respectively. Fig. 7 shows the SEM micrograph and the EDAX of the alkali activated GGBFS paste with K_2O content of 4% and 6 %, at curing time of 28 days. The matrix of AABFS4-8 which was not fairly uniform. Some of the slag grains were not dissolved in alkaline solution. As seen from EDAX, the increase in Ca/Al (2.26) and Si/Al (2.38) ratio occurs with incorporation of the activators. The matrix of AABFS6-8 was having some fine pores on the surface of the specimens with some partially dissolved slag grains as observed in Fig. 7. This indicated that, not all the slag grains form C-S-H gel, the decrease in Ca/Si (0.79), Ca/Si (1.73) and Si/Al (2.18) was observed.

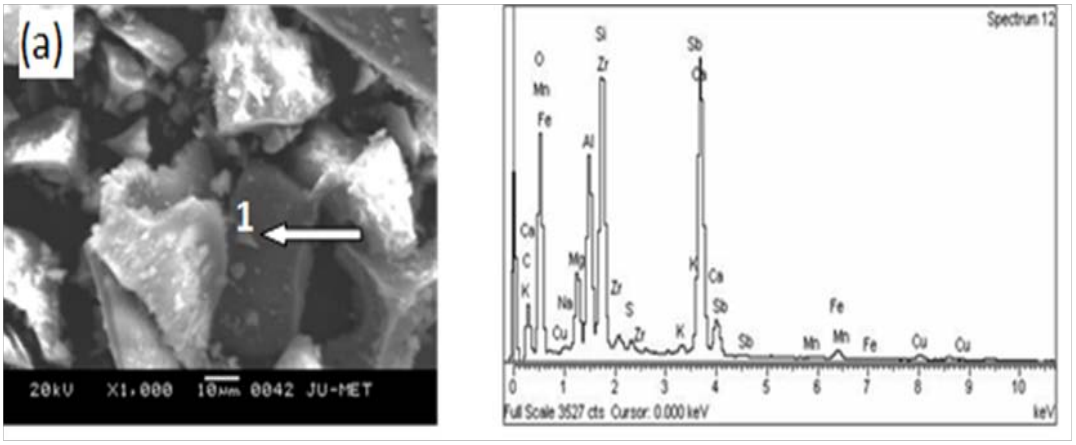
Fig. 8 show SEM micrographs and EDAX results of alkali activated GGBS with K_2O content of 8% and 10%. It can be seen that the paste obtained by activation using a lower percentage of K_2O content shows more unreacted slag grains as compared to the paste obtained form activation using a higher percentage of K_2O, resulting increase in C-S-H gel formation which in turns increase in compressive strength. Thus the matrix of AABFS8-8 was little different from other type of specimens as the microstructure was very dense with fewer unreacted

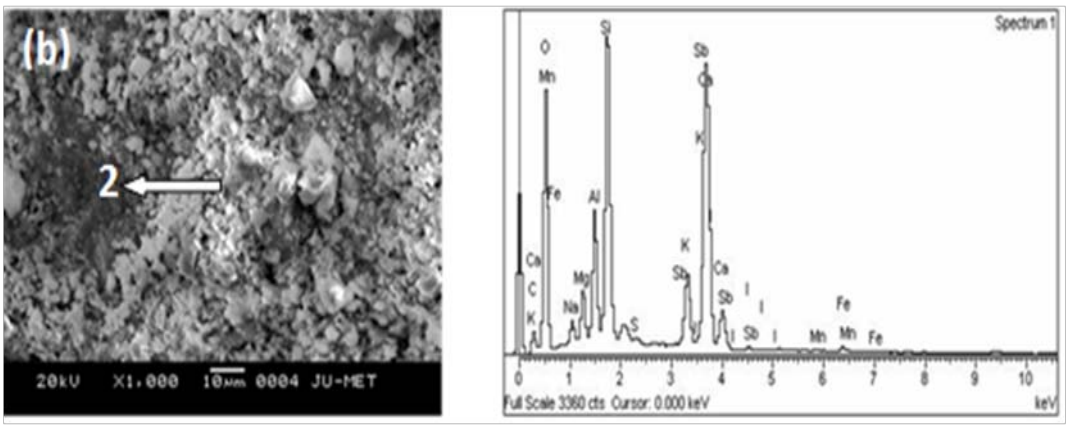
slag grains and less micro cracks and porosity, hence responsible for higher strength. Spot analysis at the arrow pointer of EDAX spectrum indicates that there was an increase in atomic % of Ca/Si (0.97), Ca/Al (2.3) and Si/Al (2.36) ratio with 8 % of K_2O. Silicates anions of alkaline solutions increases, the Ca/Si ratio in the main C-S-H decreases and the contents of of Q3 units increases resulting in an increase in compressive strength.(Jimenez and Puertas, 2003). The matrix of AABFS10-8 was very dense with fewer unreacted slag grains. But some micro cracks were found on the border of C-S-H and unreacted silica which reduces the strength compared to AABFS8 8 specimens.

The major hydration product found in all alkali activated GGBS specimens was amorphous to poorly crystalline C-S-H (I) gel with Ca/ Si ratio ranging from 0.79 – 1.01

Table 4 : Semi- quantitative elemental analysis of raw slag and alkali activated blast furnace slag by EDAX; points of analysis are shown in Fig. 7 and 8

Spot	Element atomic ratio (%)								Ratio		
	Na	Mg	Al	Si	S	K	Ca	Fe	Ca/Si	Ca/Al	Si/Al
Arrow-1	0.19	2.3	4.16	6.26	0.21	0.15	6.79	0.38	1.08	1.63	1.50
Arrow-2	1.45	2.14	4.0	9.55	0.15	1.88	9.04	0.22	0.94	2.26	2.38
Arrow-3	1.07	2.28	4.09	8.92	0.3	1.75	7.11	0.15	0.79	1.73	2.18
Arrow-4	1.29	3.24	5	11.82	0.45	2.89	11.52	0.3	0.97	2.3	2.36
Arrow-5	0.92	2.03	3.76	8.61	0.31	2.26	8.70	0.26	1.01	2.31	2.28





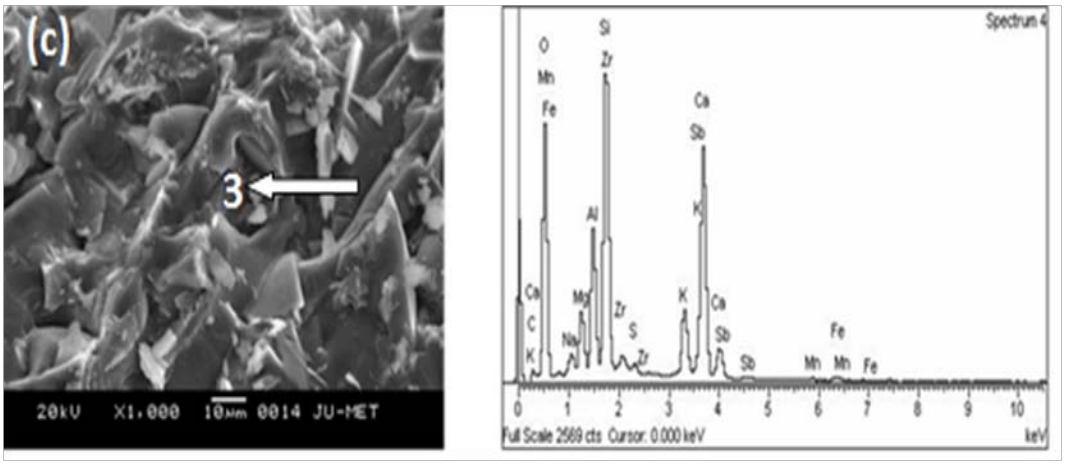


Figure 7 : SEM-EDX characterization of raw slag and alkali activated blast furnace slag paste with 4 % K_2O (AABFS4-8) and 6% K_2O (AABFS6-8) at a curing time of 28 days

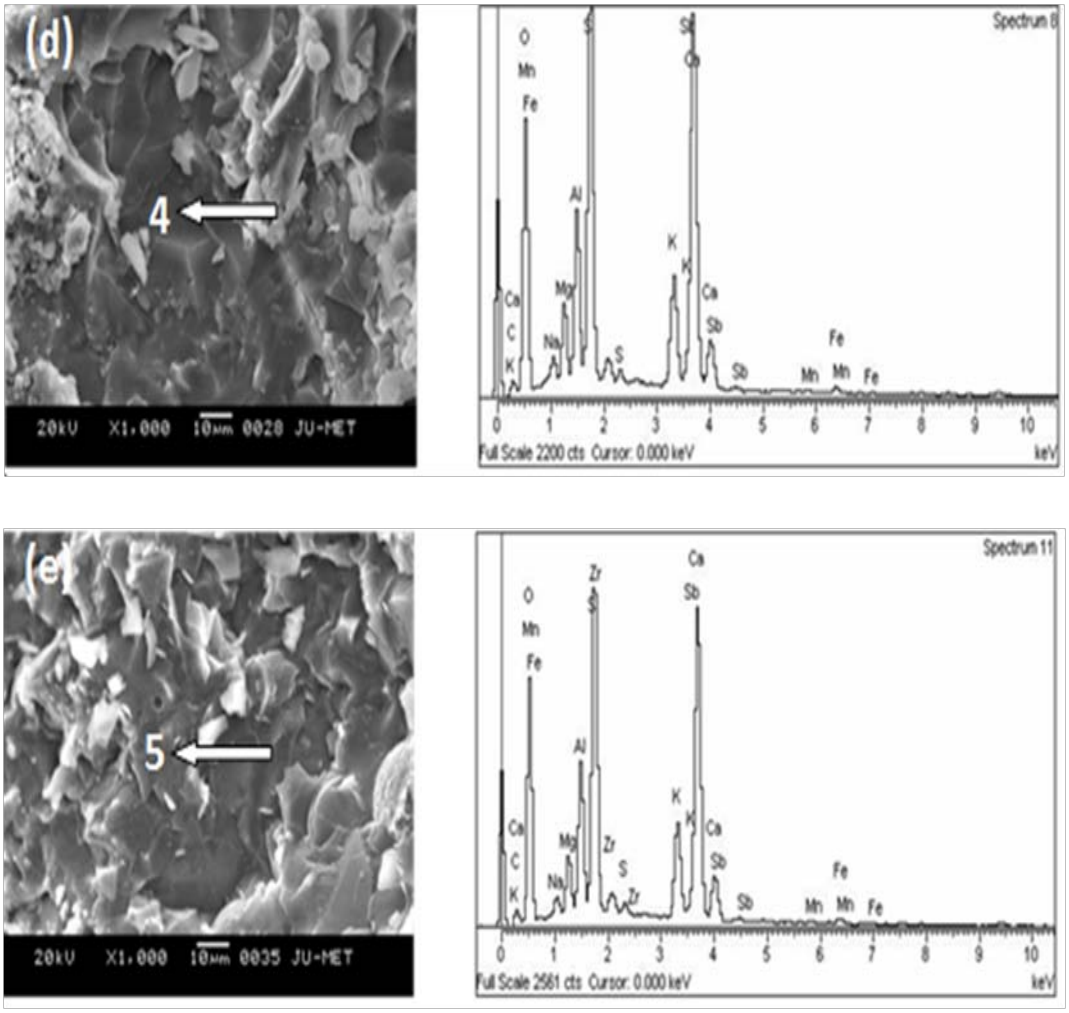


Figure 8 : SEM-EDAX characterization of alkali activated blast furnace slag paste. (d) 8 % K_2O (AABFS8-8) and (e) 10% K_2O (AABFS10-8) at a curing time of 28 days

IV. Conclusions

The effect of alkali content (% K_2O) on the direct compressive strength of AABFS paste specimens has been investigated. Based on experimental study, the following conclusions are drawn.

1. The K_2O dosage had a significant influence on the strength of AABFS paste. The K_2O is needed to maintain the alkalinity of the mixes, the condition needed to assist the dissolution of slag and the adsorption of ions in solution on the surface of slag.
2. The rate of increase in compressive strength with an age also depends upon the percentage of alkali content. Maximum compressive strength and split tensile strength was found to be 51.44 MPa and 5.81 MPa for 8 % K_2O by keeping % SiO_2 equal to 8%.
3. The major hydration product found in all alkali activated GGBS specimens was amorphous to poorly crystalline C-S-H (I) gel with a Ca / Si ratio of 0.79 – 1.01.
4. As the percentage of alkali content increases from 4 % to 8 %, it in turn increases the C-S-H gel and thus increases denseness of the matrix and refines the pore structure, as observed in an SEM study.
5. The optimum silicate modulus SiO_2 / (K_2O+Na_2O) of AAGBFS paste was found to be around 0.8 (Fig.4).
6. The compressive strength of the paste can be controlled by judiciously choosing the K_2O percentage and silicate modulus.

References Références Referencias

1. Wang S., Scrivener K.L., Pratt P.L. (1994). Cem Concr Res 24 (6), 1033–1043.
2. Bakharev T., Sanjayan J.G., Cheng Y.B. (1999). Alkali activation of Australian slag. Cement and Concrete Research 29, 113–120.
   Osborn E.F., DeVries
3. R.C., Ghee K.H., Kraner H.M. (1954). Optimum composition of blast furnace slag as deduced from liquids data for the quaternary system CaO-MgO-Al_2O_3-SiO_2. Journal of Metal, 6(1), 33-34.
4. Glukhovsky V.D., Pakhomov V.A. (1978). Slag-Alkali Cements and Concretes. Budivelnik Publishers, Kiev, Russia.
5. Shi C, Li Y. and Tang X. (1989). A preliminary investigation on the activation mechanism of granulated phosphorus slag. Journal of Southeast University, Nanjing, P.R. China, 19 (1), 141-145.
6. Collins F., Sanjayan J.G. (1998). Cem Concr Res 28 (5) (1998) 655–664.
7. Shi C., Li Y. (1989 a). Investigation on some factors affecting the characteristics of alkali- phosphorus slag cement. Cement and Concrete Research, 19(4), 527-533.
8. Shi C., Li Y. and Tang X. (1989 b). Studies on the activation of phosphorous slag. Supplementary Paper, 3rd International conference on the use of Fly Ash, Silica Fume, Slag and natural Pozzonans in concrete, ACI SP-114, Trondheim, Norway, 657-666.
9. Krivenko P.V. (1992). Alkaline cements. 9th International Congress on the chemistry of Cement, New Delhi, India, IV, 482-488.
10. Fernandez Jiminez A. and F.Puertas F.(2003). Effect of activator mix of the hydration and strength behavior of alkali-activated slag cements, Advances in Cement Research, 15 (3), 129-136.

This page is intentionally left blank

Global Journal of Researches in Engineering
Civil And Structural Engineering
Volume 13 Issue 1 Version 1.0 Year 2013
Type: Double Blind Peer Reviewed International Research Journal
Publisher: Global Journals Inc. (USA)
Online ISSN: 2249-4596 & Print ISSN: 0975-5861

Rooftop Rain Water Harvesting for Groundwater Recharge in an Educational Complex

By Dr. Arun Kumar Dwivedi, Virendra B. Patil & Amol B. Karankal
S.S.V.P.S.B.S.Deore College of Engineering, Dhule (MS) India

Abstract - The rainwater harvesting locally collects and stores rainfall through different technologies, for future use to meet the demands of human consumption or human activities. However, rainwater harvesting has much wider perspectives, in particular, if it is considered in relation to its role in supporting ecosystem goods and services.

An integrated planning for Rooftop Rain Water Harvesting system for different institutes in the premises an educational complex is done. The main objectives of the study are to estimate the rooftop rain water harvesting potential of all buildings, planning and designing the rooftop rain water harvesting system, the conveyance system and the groundwater recharge system. The cost estimation of different components of roof top rain water harvesting project for each zone is done. The annual equivalent capital cost is estimated with and without the cost of ground water recharge structure. The unit cost of water is high as compared to the market price of water. However, the environmental benefits of the ground water recharging with good quality water justifies such projects.

Keywords : *cost of water, groundwater recharge structure, rain water harvesting, rooftop rain water.*

GJRE Classification : *FOR Code : 090508, 090599*

Strictly as per the compliance and regulations of :

Rooftop Rain Water Harvesting for Groundwater Recharge in an Educational Complex

Dr. Arun Kumar Dwivedi [α], Virendra B. Patil [σ] & Amol B. Karankal [ρ]

Abstract - The rainwater harvesting locally collects and stores rainfall through different technologies, for future use to meet the demands of human consumption or human activities. However, rainwater harvesting has much wider perspectives, in particular, if it is considered in relation to its role in supporting ecosystem goods and services.

An integrated planning for Rooftop Rain Water Harvesting system for different institutes in the premises an educational complex is done. The main objectives of the study are to estimate the rooftop rain water harvesting potential of all buildings, planning and designing the rooftop rain water harvesting system, the conveyance system and the groundwater recharge system. The cost estimation of different components of roof top rain water harvesting project for each zone is done. The annual equivalent capital cost is estimated with and without the cost of ground water recharge structure. The unit cost of water is high as compared to the market price of water. However, the environmental benefits of the ground water recharging with good quality water justifies such projects.

Keywords : cost of water, groundwater recharge structure, rain water harvesting, rooftop rain water.

I. Introduction

a) Concept of Rain Water Harvesting

The rainwater harvesting consists of a wide range of technologies used to collect, store and provide water with the particular aim of meeting demand for water by humans and/or human activities, which is explained schematically in Figure-1. These technologies can be divided into two main areas depending on source of water collected; namely, the in situ and the ex situ types of rainwater harvesting, respectively.

Author α : Professor & Head, Department of Civil Engineering, S.S.V.P.S.B.S.Deore College of Engineering, Dhule (MS) India 424 005
E-mail : akd321@gmail.com
Author σ : Lecturer, Department of Civil Engineering, Government Polytechnic, Deopur, Dhule (MS) 424 005.
E-mail : patilvaibhav29@rediffmail.com
Author ρ: Assistant Professor, Department of Civil Engineering, SSVPS BSD College of Engineeering, Deopur, Dhule (MS) 424 005.
E-mail : amolprabha@gmail.com

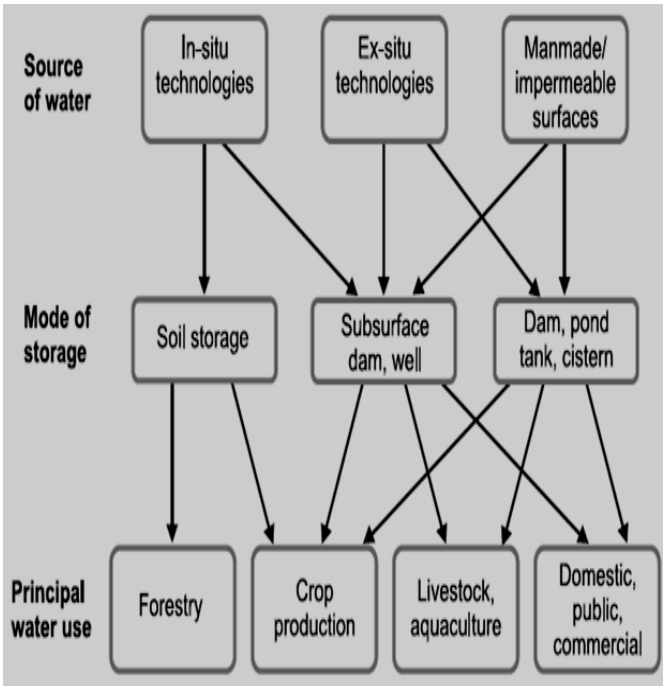


Figure 1 : "Schematic Diagram showing the rainwater harvesting technologies based on source of water and water storage type" [UNEP(2009)]

b) Need For Rainwater Harvesting

Due to over population and higher usage levels of water the surface sources are being over stressed which has led to boring of tube wells at individual as well as at local government's level. The replenishment of ground water (GW) is drastically reduced due to paving of open areas. Indiscriminate exploitation of GW results in lowering of ground water table (GWT) rendering many bore-wells dry. To overcome this situation bore wells are drilled to greater depths. This further lowers the GWT and in some areas this leads to higher concentration of hazardous chemicals such as fluorides, nitrates and arsenic. In coastal areas, over exploitation of GW results in seawater intrusion thereby rendering GW bodies' saline. In rural areas also, government policies on subsidized power supply for agricultural pumps and piped water supply through bore wells are resulting into decline in GWT. The solution to all these problems is to replenish GW bodies with rainwater by manmade means.

c) Indian Scenario: Rain Water Harvesting

The annual precipitation in India is estimated on an average 1100 mm. Although its distribution in space and time is highly variable, most of it is allowed to go waste as run-off water into the sea through the river system. The Government of India (GoI) is also promoting rainwater harvesting through watershed management programme, artificial recharge of GW and roof top rain water harvesting (RRWH) under various schemes. The main function of the urban local bodies is to guide the development according to the master plan prepared by the town & country planning departments and to provide and maintain the services like water supply, sanitation and transportation. The major flaw in these planning processes is that the building bye-laws and development charges do not encourage citizens to adopt RRWH and other measures to conserve the water. Also as water is being supplied at greatly subsidized rates, cost of water is between Rs 8.10 to Rs 6.10 per Kilo-liter at 1998-1999 prices while it is supplied at less than Rs 2.00 per Kilo-liter [GoI (2004)], by the urban local bodies so people are not encouraged to adopt the rain water harvesting which in turn is depleting the precious available water resources resulting in shortage of water in the urban areas. To overcome these problems there is a need to adopt water sensitive development controls as part of the building bye-laws in the master plan of the urban area itself. [Chakrabarti (2000)]

II. Description of Project Area

a) Location

The Dhule town is located at latitude 21°10' and longitude 75°20', lying 57 km. north of Chalisgaon Bombay-Nagpur route of the central railway. The SSVP Sanstha is rendering the valuable services in the field of education for the people living in the Dhule town district, for last 104 years. The main campus of the SSVP Sanstha is located in Vidyanagari area of Dhule town. The campus includes the Science College, Arts College and Commerce College offering secondary and post secondary education along with an engineering college, polytechnic since 1983 and a School, since 2007. The area of these five institutes is clearly demarcated for educational activities; however there is lot of area which is being shared for practical purposes. The administrative and educational working of all these five institutions is independent.

b) Necessity of Project

The water resources and the drainage system in the premises of these five institutes are shared. The gross area of the premises is 77,700 sqm, out of which 37 numbers of buildings in the premises constitutes 24938 sqm roof top areas. In present situation the rainwater from this huge roof top area is drained out of campus to nearby stream as overland flow and the guided flow through existing drainage network at some places. The overland flow leads to the erosion of soil from unpaved area in premises and chocking of the existing drainage system due to silting. This huge roof top area, if used for RWH, has immense potential for GW recharging. This will result in rise in GWT which in turn will increase the yield of the open dug wells and also the duration of their services. The benefits of the rise in GWT will be not being limited to the SSVPS premises; the nearby area will also be benefited from it. It will be an added advantage as discharge of institute's social responsibility. The GW recharge will also dilute the poor quality water percolated in the GW throughout the year from the two number of unlined streams (Nalas), carrying the waste water discharge from residential area located on north and west side of the residential area. The success chronicle of the proposed RWH project will motivate the other institutes, premises and big housing projects to adopt such installation to make the better environment.

III. Methodology for Planning & Design

a) Assumptions

The following are the assumptions; which are made in this proposed RRWH project-

- The rainfall intensity is taken as 50 mm per hour with the help of map, instead of actual applicable for Dhule region.
- The life of the RRWH system is considered as 40 years & the annual rate of interest is taken as 4% for calculating the annual equivalent cost (AEC) of the system.
- It is assumed that 40% of quantity of water which is recharged in ground is utilizable during lean period.

b) Buildings and Rooftop Area

An integrated planning for RRWH system for all five institutes is proposed. The entire area is divided in six zones, each having individual ground water recharge structure (GWRS). These six zones are shown in Figure - 2. All the buildings in premises are coded showing the institute's to which they belong and the number of building.

Figure 2 : "Boundaries & Buildings in Six Zones for RRWH"

The codes of buildings are A, B, C, D & E for North Point school, Engineering College, Polytechnic, Science College and Arts and Commerce College respectively, along with the number of particular building. The two codes for a building mean that the building is shared by two respective institutes. The area of each building in different zones and their height are given in Table-1. These zones are planned by considering the elevation of GWRS with respect to the elevation of buildings in such a way that the harvested rain water from rooftop will reach to it under gravity through underground conveyance system. All the major buildings are divided into two or more parts depending upon their rooftop area and zones.

Table 1 : "Rooftop Area Statistics – Zone Wise"

Sr	ZONE	Code	Effective Area (Sqm)	Ht (m)	Type	Sr	ZONE	Code	Effective Area (Sqm)	Ht (m)	Type
1	ZONE-I	A-1	184.87	7.2	SR	1	ZONE-IV	C-9	684.00	9.4	FR
2		A-2	178.50	2.7	SR	2		BC-10	1800.00	3.4	SR
3		A-3	2549.00	9.7	FR	3		B-11	1500.00	9.4	FR
4		A4	636.00	3.4	FR	4		DE-6	600.00	6.4	FR
5		BC-1	106.32	6.4	FR	5		D-5	330.00	6.4	FR
6		BC-2-1	468.58	9.8	FR	6		D-3	300.00	6.4	FR
7		DE-14	581.10	3.4	FR	7		D-4	300.00	6.4	FR
		SUM	**4704.37**					SUM	**5514.00**		
1	ZONE-II	BC-2-2	365.64	9.8	FR	1	ZONE-V	DE-17	258.00	6.4	FR
2		BC-3	587.57	9.4	SR	2		DE-16	330.00	6.4	FR
3		B-4	736.15	9.4	SR	3		BC-12	105.00	6.4	FR
4		B-5-1	2009.40	9.4	SR	4		BC-13	420.00	6.4	FR
5		BC-15	316.80	2.7	SR	5		BC-14	565.00	6.4	FR
6		DE-15	561.56	6.7	FR	6		DE-18	400.00	3.0	FR
		SUM	**4577.12**			7		DE-7-1	432.00	6.4	FR
1	ZONE-III	B-5-2	1811.95	9.4	FR	8		D1	504.00	6.4	FR
2		BC-6	699.61	6.4	FR	9		D2	432.00	6.4	FR
3		C-7-1	581.10	9.4	FR			SUM	**3014.00**		
4		C-7-2	741.32	9.4	FR	1	ZONE-VI	D-7-2	324.00	6.4	FR
5		C-8	620.34	9.4	SR	2		E-8	444.00	6.4	FR
		SUM	**4454.32**			3		E-9	444.00	3.2	FR
1	ZONE-IV	C-9	684.00	9.4	FR	4		DE-10	540.00	6.4	SR
2		BC-10	1800.00	3.4	SR	5		E-11	109.20	6.4	FR
3		B-11	1500.00	9.4	FR	6		DE-12	158.40	6.4	SR
4		DE-6	600.00	6.4	FR	7		E-13	544.50	6.4	FR
5		D-5	330.00	6.4	FR			SUM	**2564.10**		
6		D-3	300.00	6.4	FR		GRAND SUM		**24938.00**		
7		D-4	300.00	6.4	FR						
		SUM	**5514.00**								

c) Design Steps

The methodology for the planning and designing of RRWH system in each zone is explained in following steps;

- The route of RCC pipe below ground is finalized with the location of intake chambers to collect the harvested water from the different buildings of zone and to discharge it in GWRS.
- The area of each building in the zone is calculated and the planning for horizontal drain pipe on wall (HPW) or gutter at the edge of sloping roof (HGW) and vertical drain pipe on wall (VPW) is done in such a way that the VPW will discharge into one or two intake chambers depending upon the size of rooftop and location of chamber.
- In case of sloping roof the area of rooftop is increased by 20% for pitch more than 25° and 10% for less than 25°. The increased area is taken for calculation purpose.
- The HPW, HGW and VPW are designed as per norms as discussed. The rate of flow of each VPW discharging into different intake chamber is calculated.
- The RCC pipes below ground are designed for the corresponding discharge and available ground slope. The size of intake chamber is selected on the basis of available ground slope. In case of flatter slope the intake chamber of higher size may be selected.
- The open dug well is the most suitable GWRS option in the area. An open dug well of 6.0 m diameter with horizontal bores of 115 mm diameter, 6 Nos. of length 30 m each are proposed.

d) Cost Estimation

The cost estimation of different components of RRWH project for each zone is done on the basis of District Schedule of Rates (DSR) of Maharashtra Jeevan Pradhikaran (MJP) for year 2010-11. The cost of semicircular gutters is considered as 67% cost of pipe of same size. The cost of minor fittings in PVC gutters and pipes are taken as 5% of the cost of same. The correct alignment and proper fitting of pipes and gutters in building is essential to avoid malfunctioning of the system and hence a special provision of 10% cost of pipes and gutter is kept for this purpose. The cost estimation of special structures, i.e. intake chamber and chamber with vent pipe is done separately and the same cost is taken. The life of the RRWH system is considered as 40 years and the annual rate of interest is taken as 4%, which is normally the interest of soft loan by various financial institutions for the purpose of calculation of annual cost of the project.

e) Sample Calculations for Zone : I

The list of buildings and their rooftop type and area is given in Table – 1. The total effective rooftop area in the zone is 4704.37 sqm. The average annual monsoon rainfall with 60% probability is 494.94 mm and is considered for calculating the RRWH volume. The planning for route of underground drainage system is shown in Figure -3, which also shows the ground RLs and the chainage of various intake chambers.

POINTS	CHAINAGE	Ground RL
	m	m
IC-1	0	263.285
IC-2	60	262.605
IC-3	74	261.890
IC-4	130	261.390
IC-5	137	261.295
IC-7	208	260.950
IC-8	234	260.455
GWRS-I	273	260.375
IC-6	0	262.055
IC-7	35	260.950
IC-9	0	260.975
GWRS-I	25	260.375

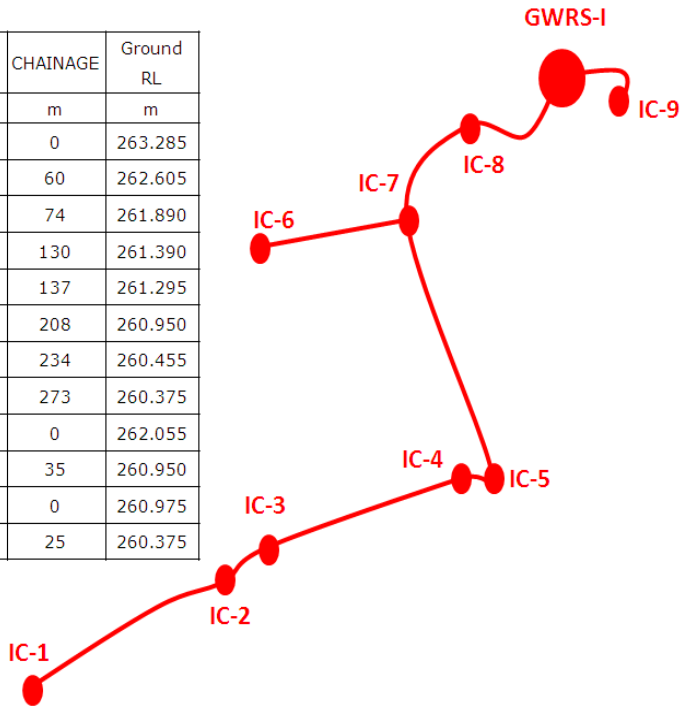


Figure 3 : Conveyance System below Ground for Zone-I

The PVC gutter for sloping roof i.e. HGW, PVC drain pipes on wall i.e. HPW and VPW are designed for all seven buildings in zone-I. The detailed are shown in Table-A.1 attached in appendix.

After planning and designing the RRWH system for all buildings, the rainwater discharge at each intake chamber is summed up and the size of underground pipe line system is calculated. The detailed calculations for the sizes of the underground reinforced cement concrete (RCC) pipes are shown in Table – A.2. The chamber with vent pipe are proposed at an average distance of 30 m or at the places of change in direction. The height of the intake pipe in intake chamber is taken as per the availability of ground slope to avoid the deep excavation.

The abstract of estimate for RRWH system for zone-I is shown in Table – A.3. The GWRS is open dug well of 6.0 m diameter, 15 m deep and 30 m x 6 Nos of horizontal bores of 115 mm size. The AEC is estimated with and without the cost of GWRS.

IV. Conclusions

a) Cost Analysis

The total capital cost and its breakdown such as cost of pipes in buildings, conveyance system below GL and the cost of GWRS for all the six zones are shown in Figure - 4.

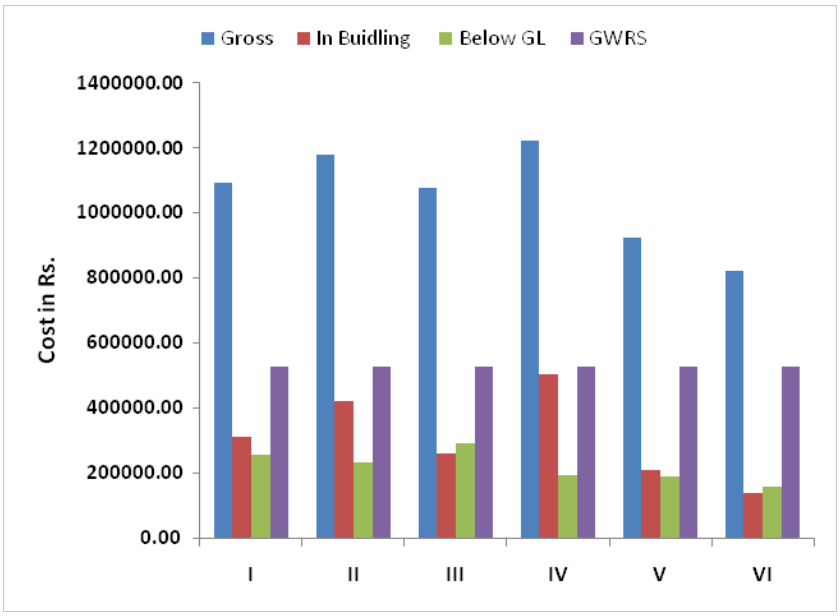


Figure 4 : Cost Breakdown of RRWH System in All Six Zones"

The unit cost of water with and without GWRS for 100% & 40 % utilizable quantity is shown in Figure -5.

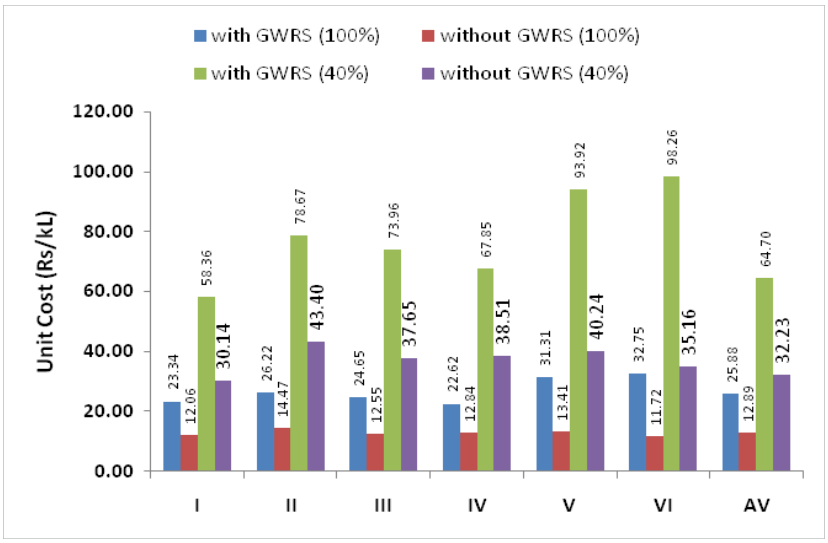


Figure 5 : Unit Cost in All Six Zones

The AEC versus the RRWH potential of all six zones is shown in Figure 6.

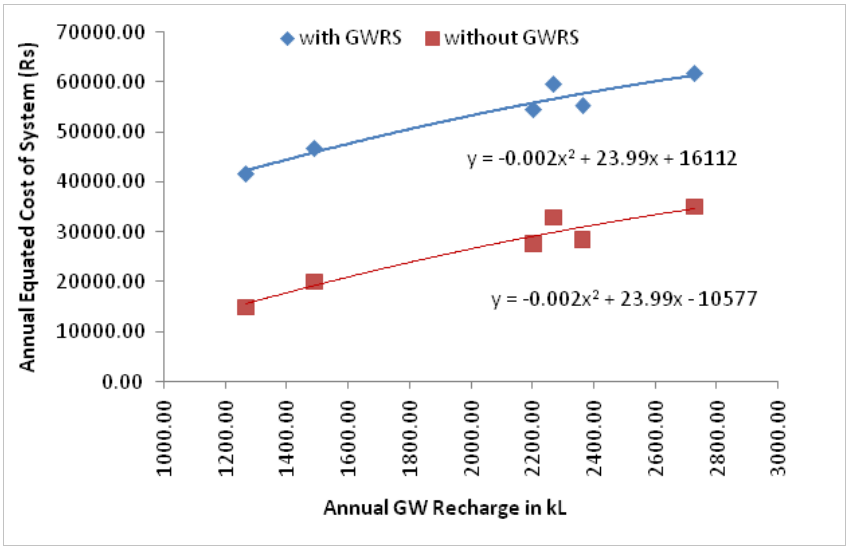


Figure 6 : Annual equated cost versus Annual GW Recharge

The split of costs in % of gross cost of different elements of RRWH system i.e. pipes in buildings, pipes below ground and ground water recharge structures for whole premises is shown in Figure-7.

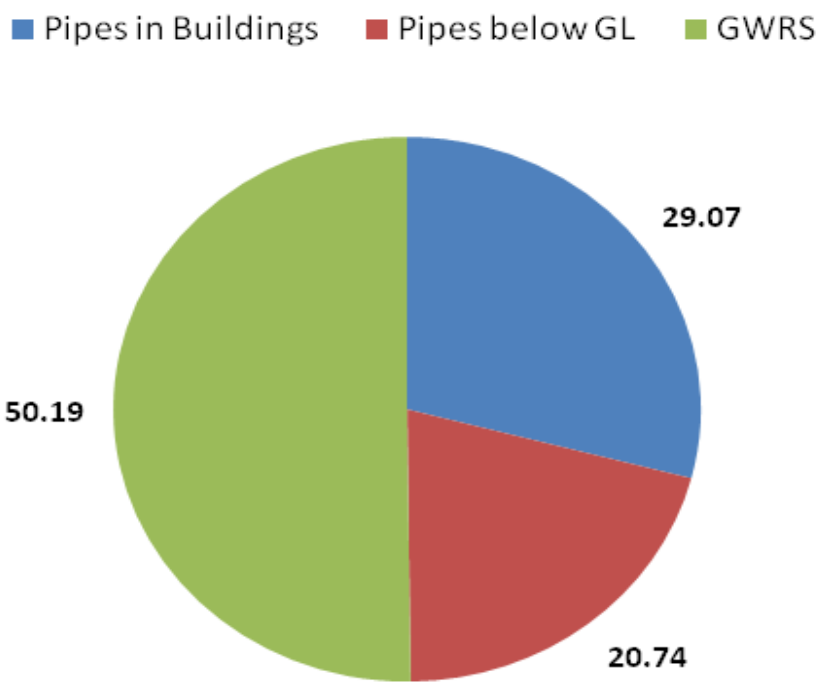


Figure 7 : % of Cost of Different Elements w.r.t. Gross Cost

b) Comments

The 40% utilization of recharged water is taken as a real life situation. The unit cost of recharged GW as calculated for the two scenarios, i.e. by considering the 100% water utilizable and second only 40% water is utilizable. In both the cases the cost is higher as compared to the market price of water. However, the environmental benefits of the ground water recharging with good quality water justifies such projects.

It is evident from Figure -7, that 50% is the cost of GWRS. These structures are not meant only for recharging purpose. These may be used the ground water resource structure, to tap the recharged water. Hence, the full cost of these structures on the part of the RRWH system cannot be justified.

c) Future Scope

There is enough quantity of rain water, which can harvested from the play grounds, paved and semi-

paved circulation area and the garden area of the institute premises. These areas are around 3 – 4 times the rooftop area in the institute's premises. In the case study of SSVPS premises, which is presented here, the rooftop area is around 1/3rd of the gross area. If the RW from remaining area is harvested for GW recharge, through the proposed GWRS, the unit cost will have steep fall and the project may become financially more viable. Thus, the micro-level study of RWH from the remaining area of premises along with the water requirement of the premises may add new dimension to such project.

References Références Referencias

1. BIS (1742-1983), "Code of Practice for Building Drainage", Reaffirmed in 1996, Bureau of Indian Standard, Manak Bhavan, 9, Bahadur Shah Jafar Narg, New Delhi, 110 002, 1996.
2. CGWB (1999), "Activities and Achievements of Central Ground Water Board on Rain Water Harvesting and Artificial Recharge", Central Ground Water Board, Ministry of Water Resources, Government of India, New Delhi, 1999.
3. Garg (2006), Santosh Kumar Garg, "Sewage Disposal & Air Pollution Engineering", 18th Edition, Khanna Publishers, 2-B, Nath Market, Nai Sadak, Delhi-110 006, 2006.
4. Gould et al (1999), Gould, John and Nissen-Petersen, Erik, "Rainwater Catchment Systems for Domestic Security", London, UK, Intermediate Technology Publications (ISBN 1853394564), 1999.
5. Jacob (2008), "Rooftop Rainwater Harvesting for Rural Schools in Karnataka – Experiences", Solution Exchange for the Water Community Consolidated Reply Query : Compiled by Nitya Jacob, Resource Person and Ramya Gopalan, Research Associate, 9 May 2008.
6. Jebamalar and Ravikumar (2011), A. Jebamalar and G. Ravikumar, "A comparative analysis of hydrologic responses to rainwater harvesting – A case study", Indian Journal of Science and Technology, Vol. 4 No. 1 (Jan 2011) ISSN: 0974-6846, pp : 34-39.
7. Khare, Ojha and Srivatsava (2004), Deepak Khare, Ramakand, Ojha and Srivatsava RK, "Impact assessment of rainwater harvesting on ground water quality at Indore and Dewas, India", Journal of Indian Water Works Association, Volume-36(2), pp : 123-128.
8. MOWR (2002), "Thirty Fourth Report Ministry of Water Resources Demands For Grants 2002 – 2003", Ministry of Water Resources Government of India, New Delhi, 2002.
9. Patil (1999), Subhash M. Patil, "Plumbing Engineering – Theory, Design & Practice)", Revised & Enlarged Edition, Seema Publication, A2-9/003, Nirmal Society, Gokul Dham, Goregaon (E), Mumbai, 400 063, 1999.
10. Sharma and Jain (1997), Sharma SK and Jain SK, "Ground water recharge through roof top rain water harvesting in urban habitation", International Conference on Management of Drinking Water Resources", 1997, pp :60.
11. UNEP (2009), "Rainwater Harvesting : A Lifeline For Human Well-Being", A report prepared for UNEP by Stockholm Environment Institute, Division of Environmental Policy Implementation United Nations Environment Programme (UNEP), P.O. Box 30552, Nairobi, Kenya, 2009.
12. Wong (2011), Jason J. Wong, "Optimizing Rainwater Harvesting Installation in Kashongi, Uganda: Sustainable Rural Water Supply, Collective Action and Institutions", Graduate Thesis, Duke University Durham, North Carolina, 2011.

Table A.1 : Design of RRWH System for All Buildings in Zone-I

1	Building Code & Roof Type						A-1 : SR	
	Plan Area A (m^2)			184.87	Effective Area A_{eff} (m^2)			221.84
	Annual RRWH Potential (kL)			109.80	Total Discharge from Rooftop (LPS)			3.08
	Design of Rainwater Collection System on Wall/Roof							
	From	To	L (m)	CA (m^2)	Q (LPS)	Size (mm^2)	Dia (mm)	TYPE
	1	2	13.00	110.92	1.54	5546.10	160.00	HG
	3	4	13.00	110.92	1.54	5546.10	160.00	HG
	4	5	13.00	110.92	1.54	5546.10	110.00	HPW
	4	IC-1	7.20	221.84	3.08	5546.10	110.00	VPW
2	Building Code & Roof Type						A-2 : SR	
	Plan Area A (m^2)			178.50	Effective Area A_{eff} (m^2)			214.20
	Annual RRWH Potential (kL)			106.02	Total Discharge from Rooftop (LPS)			2.98
	Design of Rainwater Collection System on Wall/Roof							
	From	To	L (m)	CA (m^2)	Q (LPS)	Size (mm^2)	Dia (mm)	TYPE
	1	2	17.00	107.10	1.49	5355.00	160.00	HG
	3	4	17.00	107.10	1.49	5355.00	160.00	HG
	4	5	11.00	107.10	1.49	5355.00	110.00	HPW
	4	IC-2	2.70	214.20	2.98	5355.00	110.00	VPW

3	Building Code & Roof Type						A-3 : FR	
	Plan Area A (m^2)			2549.00	Effective Area A_{eff} (m^2)			2549.00
	Annual RRWH Potential (kL)			1261.60	Total Discharge from Rooftop (LPS)			35.40
	Design of Rainwater Collection System on Wall/Roof							
	From	To	L (m)	CA (m^2)	Q (LPS)	Size (mm^2)	Dia (mm)	TYPE
	1	2	31.50	312.90	4.35	15645.00	160.00	HPW
	2	3	31.50	625.80	8.69	31290.00	225.00	HPW
	3	IC-3	9.70	938.70	13.04	23467.50	200.00	VPW
	4	5	20.00	215.76	3.00	10788.00	140.00	HPW
	5	6	22.10	431.52	5.99	21576.00	180.00	HPW
	7	8	26.40	316.63	4.40	15831.25	160.00	HPW
	8	6	26.40	633.25	8.80	31662.50	225.00	HPW
	6	IC-4	9.70	1064.77	14.79	26619.25	200.00	VP
	9	10	20.00	215.76	3.00	10788.00	140.00	HPW
	10	11	22.10	431.52	5.99	21576.00	180.00	HPW
	11	IC-7	9.70	431.52	5.99	10788.00	140.00	VPW
4	Building Code & Roof Type						A-4 : FR	
	Plan Area A (m^2)			636.00	Effective Area A_{eff} (m^2)			636.00
	Annual RRWH Potential (kL)			314.78	Total Discharge from Rooftop (LPS)			8.83
	Design of Rainwater Collection System on Wall/Roof							
	From	To	L (m)	CA (m^2)	Q (LPS)	Size (mm^2)	Dia (mm)	TYPE
	1	2	26.50	134.68	1.87	6734.00	110.00	HPW
	2	4	24.00	269.36	3.74	13468.00	140.00	HPW
	3	4	26.50	134.68	1.87	6734.00	110.00	HPW
	4	IC-6	3.40	636.00	7.48	15900.00	140.00	VPW
5	Building Code & Roof Type						DE-14 : FR	
	Plan Area A (m^2)			581.10	Effective Area A_{eff} (m^2)			581.10
	Annual RRWH Potential (kL)			287.61	Total Discharge from Rooftop (LPS)			8.07
	Design of Rainwater Collection System on Wall/Roof							
	From	To	L (m)	CA (m^2)	Q (LPS)	Size (mm^2)	Dia (mm)	TYPE
	1	2	14.90	193.70	2.69	9685.00	125.00	HPW
	2	3	14.90	387.40	5.38	19370.00	180.00	HPW
	3	4	14.90	581.10	8.07	29055.00	225.00	HPW
	4	IC-5	3.40	581.10	8.07	14527.50	160.00	VPW
6	Building Code & Roof Type						BC-1 : FR	
	Plan Area A (m^2)			106.32	Effective Area A_{eff} (m^2)			106.32
	Annual RRWH Potential (kL)			52.62	Total Discharge from Rooftop (LPS)			1.48
	Design of Rainwater Collection System on Wall/Roof							
	From	To	L (m)	CA (m^2)	Q (LPS)	Size (mm^2)	Dia (mm)	TYPE
	1	2	5.30	53.16	0.74	2658.00	75.00	HPW
	2	3	5.30	106.32	1.48	5316.00	90.00	HPW
	3	IC-8	6.40	106.32	1.48	2658.00	75.00	VPW
7	Building Code & Roof Type						BC-2-1 : FR	
	Plan Area A (m^2)			468.58	Effective Area A_{eff} (m^2)			468.58
	Annual RRWH Potential (kL)			231.92	Total Discharge from Rooftop (LPS)			6.51
	Design of Rainwater Collection System on Wall/Roof							
	From	To	L (m)	CA (m^2)	Q (LPS)	Size (mm^2)	Dia (mm)	TYPE
	1	2	19.50	117.22	1.63	5861.00	110.00	HPW
	2	6	19.50	234.44	3.26	11722.00	140.00	HPW
	3	4	14.00	78.14	1.09	3907.00	90.00	HPW
	4	5	14.00	156.28	2.17	7814.00	110.00	HPW
	5	6	14.00	234.42	3.26	11721.00	140.00	HPW
	6	IC-9	9.80	468.58	6.51	11714.38	140.00	VPW

- SR - Sloping Roof, HG-Horizontal Gutter, VP - Vertical Pipe, HPW - Horizontal Pipe on Wall
- Pitch of Roof (Degree) = 26-35, Area Correction Factor = 1.2, Rainfall Intensity - 50 mm/hour
- External Gutter Size per unit of Drainage Area - 50 mm^2/m^2,
- Horizontal Down Pipe Size per unit of Drainage Area ($< 15^O$ Slope)- 50 mm^2/m^2
- Vertical Down Pipe Size per unit of Drainage Area - 25 mm^2/m^2

Table A.2 : Design of Underground Pipe Line for Zone-I

Points	Chainage	GRL	Q-ADD at Intake Chamber	LENGTH	Q-PIPE	DROP	SL-Available (X)	Pipe Dia
	m	m	LPS	m	LPS		1 : X	mm
MAIN LINE-1								
IC-1	0.00	263.285	3.08					
				60.00	3.08	0.680	88.24	100.00
IC-2	60.00	262.605	2.98					
				14.00	6.06	0.715	19.58	100.00
IC-3	74.00	261.890	13.04					
				56.00	19.09	0.500	112.00	150.00
IC-4	130.00	261.390	14.79					
				7.00	33.88	0.095	73.68	200.00
IC-5	137.00	261.295	8.07					
				71.00	41.95	0.345	205.80	250.00
IC-7	208.00	260.950	13.47					
				26.00	55.42	0.495	52.53	250.00
IC-8	234.00	260.455	1.48					
				39.00	56.90	0.080	487.50	300.00
GWRS-I	273.00	260.375						
BRANCH LINE								
IC-6	0.00	262.055	7.48					
				35.00	7.48	1.105	31.67	100.00
IC-7	35.00	260.950	5.99					
					13.47			
MAIN LINE - 2								
IC-9	0.00	260.975	6.59					
				25.00	6.59	0.600	41.67	100.00
GWRS-I	25.00	260.375						

Table A.3 : Abstract of Estimate RWHS for Zone-I

Sr	Description of Items	Unit	Qty	Rate (Rs/Unit)	Cost (Rs)
1	PVC Pipe + Jointing				
	75 mm	RMT	11.70	110.00	1287.00
	90 mm	RMT	19.30	154.00	2972.20
	110 mm	RMT	120.70	224.00	27036.80
	125 mm	RMT	14.90	304.00	4529.60
	140 mm	RMT	120.00	382.00	45840.00
	160 mm	RMT	92.80	496.00	46028.80
	180 mm	RMT	59.10	625.00	36937.50
	200 mm	RMT	19.40	733.00	14220.20
	225 mm	RMT	41.30	945.00	39028.50
	160 mm	RMT	60.00	345.60	20736.00
2	RCC Pipe below GL				
	100 mm	RMT	134.00	284.00	38056.00
	150 mm	RMT	56.00	468.00	26208.00
	200 mm	RMT	7.00	636.00	4452.00
	250 mm	RMT	97.00	887.00	86039.00
	300 mm	RMT	39.00	1231.00	48009.00
3	Pipe Minor Fittings - Material	10% of Cost of Pipes			21788.06
4	Pipe Fixing in Wall - Labour	20% of Cost of Pipes			43576.12
5	Gutters Minor Fittings - Material	10% of Cost of Gutters			2073.60
6	Gutter Fixing in Roof - Labour	20% of Cost of Gutters			4147.20
7	Lowering & Laying - RCC Pipes				
	100 mm	RMT	134.00	31.00	4154.00
	150 mm	RMT	56.00	45.00	2520.00
	200 mm	RMT	7.00	59.00	413.00

	250 mm	RMT	97.00	79.00	7663.00
	300 mm	RMT	39.00	96.00	3744.00
8	Excavation & Refilling				
	Soft Murum (0.60 x 0.30 m)	Cum	59.94	114.00	6833.16
	Hard Murum (0.60 x 0.20 m)	Cum	39.96	127.00	5074.92
9	Intake Chamber				
	Intake Pipe 1.0 m	No	3	1207.00	3621.00
	Intake Pipe 1.5 m	No	3	1559.00	4677.00
	Intake Pipe 2.0 m	No	3	1911.00	5733.00
10	Chamber with Vent Pipe	No	11	620.00	6820.00
11	GWRS (Open Dug Well with Bore)	No	1	497450.00	528250.00
Gross Cost- Rs.					1061668.66
Cost in Building-Rs.					310201.58
Cost in Conveyance Below Ground-Rs.					223217.08
Cost of GWRS-Rs.					528250.00
Annual Quantity of RRWH-kL					2364.35
Life of Project -Years		40	Rate of Interest -		0.04
Equivalent Annual Cost Factor					0.0505
Equivalent Annual Capital Cost with GWRS -Rs.					53639.21
Equivalent Annual Capital Cost without GWRS-Rs.					26950.17
Capital Cost/kL (considering 100% utilizable) - Rs/kL-					22.69
Capital Cost/kL (without GWRS) (considering 100% utilizable) - Rs/kL-					11.40
Capital Cost/kL (considering 40% utilizable) - Rs/kL-					56.72
Capital Cost/kL (without GWRS) (considering 40% utilizable) - Rs/kL-					28.50

Global Journal of Researches in Engineering
Civil And Structural Engineering
Volume 13 Issue 1 Version 1.0 Year 2013
Type: Double Blind Peer Reviewed International Research Journal
Publisher: Global Journals Inc. (USA)
Online ISSN: 2249-4596 & Print ISSN: 0975-5861

Modeling of a Parabolic Solar-Collector System for Water Desalination

By Juma Yousuf Alaydi
Mechanical Engineering- IUG

Abstract - This paper presents the design of a parabolic-trough solar-collector system for water desalination in Gaza, Collector-aperture and rim-angle optimization together with the receiver-diameter selection are presented. A comparison of concentrating collectors against conventional flat-plate collectors is presented. It is shown that for large scale water production the parabolic-trough collectors are more efficient than the flat plate ones. The analysis considers visible radiation transfer, IR radiation exchange, conductive and convective losses and energy transferred to a fluid flowing through the collector tube. The collector may have a tilted north-south axis, an east-west axis or it may fully track the sun and geometric parameters associated with tracking the sun are considered.

Keywords : *parabolic-trough collectors, solar radiation, solar desalination.*

GJRE Classification : *FOR Code : 850303*

Strictly as per the compliance and regulations of :

Modeling of a Parabolic Solar-Collector System for Water Desalination

Juma Yousuf Alaydi

Abstract - This paper presents the design of a parabolic-trough solar-collector system for water desalination in Gaza, Collector-aperture and rim-angle optimization together with the receiver-diameter selection are presented. A comparison of concentrating collectors against conventional flat-plate collectors is presented. It is shown that for large scale water production the parabolic-trough collectors are more efficient than the flat plate ones. The analysis considers visible radiation transfer, IR radiation exchange, conductive and convective losses and energy transferred to a fluid flowing through the collector tube. The collector may have a tilted north-south axis, an east-west axis or it may fully track the sun and geometric parameters associated with tracking the sun are considered.

Keywords : parabolic-trough collectors, solar radiation, solar desalination.

I. Introduction

Gaza enjoys an abundance of solar radiation. The mean daily global solar radiation varies from about 2-3 kWh/m2 in the cloudiest months of the year (i.e. December and January) to about 8kWh/m2 in July. [1,2]. The annual global solar-radiation received on a horizontal surface, for average weather conditions, is 1725kWh/m2, 69% of this amount, (i.e. 1188 kWh/m2) reaches the surface as direct solar radiation and the rest, 31% (i.e. 537 kWh/m2), as diffuse radiation. According to Marinos et al. [3] and Morris and Hanbury [4], the worldwide installed capacity of desalinated water systems in 1990 reached 13million m3/day, which, by the year 2010, is expected to double. The dramatic increase in desalinated water supply will create a series of problems, the most significant of which are those related to energy consumption. It has been estimated that a production of 13 million m3 of portable water per day requires 130 million tons of oil per year. If desalination is accomplished by conventional technology, then it will require the burning of substantial quantities of fossil fuels. Given that conventional sources of energy are polluting, sources of energy that are not polluting will have to be used. Fortunately, there are many parts of the world that are short of water but have exploitable renewable-energy sources that could be used to drive desalination processes.

Solar desalination is used in nature to produce rain, which is the source of fresh-water supply . Solar Radiation falling on the surface of the sea is absorbed as heat and causes evaporation of the water. The vapor rises above the surface and is moved by winds. When this vapor cools down to its dew point, condensation occurs and fresh water precipitates as rain.

Solar energy can be used for sea-water desalination either by producing the thermal energy required to drive the phase-change processes or by generating the electricity required to drive the membrane processes. Solar-desalination systems are thus classified into two categories, i.e. direct and indirect collection-systems. As their name implies, direct-collection systems use solar-energy to produce distillate directly in the solar collector, whereas in indirect collection systems, two sub-systems are employed (one for solar-energy collection and one for desalination). Conventional desalination systems are similar to solar systems because the same type of equipment is applied. The prime difference is that in the former, either a conventional boiler is used to provide the required heat or mains electricity is used to provide the required electric power, whereas in the latter, solar energy is applied.

The solar Parabolic Trough Collector (PTC) model is presented in this paper. The tracking mechanism consists of a low-speed 12Vd.c motor and a control system. The input signals to the control system are obtained from three light-dependent resistors. One resistor determines whether the collector is in focus, the second determines the sun/cloud condition, while the third whether it is day or night, where the accuracy of the mechanism is also presented.

II. Solar Collector Design

From the many types of solar collectors developed, three types merit further consideration for steam generation: the parabolic-trough collector (PTC), the compound parabolic collector (CPC) and the flat-plate collector (FPC). The first one is a tracking collector, whereas the last two are stationary. PTCs are generally of medium concentration ratio (15–40) whereas CPCs are generally of low concentration ratios (1.5–5). The low concentration ratios of the latter allow them to work without a need for tracking of the Sun.

Author : Associate Prof. in Mechanical Engineering, IUG- Gaza.
E-mail : jalaydi@iugaza.edu

a) Collector Type Selection

In general, concentrating collectors exhibit certain advantages as compared with the conventional flat-plate type. The main ones are:

i. The working fluid can achieve higher temperatures in a concentrator system when compared with a flat-plate system of the same solar-energy collecting surface. This means that a higher thermodynamic efficiency can be achieved.
ii. It is possible with a concentrator system, to achieve a thermodynamic match between temperature level and task. The task may be to operate thermionic, thermodynamic, or other higher-temperature devices.
iii. The thermal efficiency is greater because of the small heat-loss area relative to the receiver area.
iv. Reflecting surfaces require less material and are structurally simpler than flat-plate collectors. For a concentrating collector, the cost per unit area of the solar collecting surface is therefore less than that of a flat-plate collector.
v. Owing to the relatively small area of receiver per unit of collected solar energy, selective surface treatment and vacuum insulation to reduce heat losses and improve the collector efficiency are often economically viable.

Their disadvantages are:

i. Concentrator systems collect little diffuse radiation, the rate depending on the concentration ratio.
ii. Some form of tracking system is required, so as to enable the collector to follow the Sun.
iii. Solar-reflecting surfaces may lose their reflectance with time and may require periodic cleaning and refurbishing.

Perhaps their most important advantage is the enhanced thermal-efficiency and therefore this is further analyzed. The thermal efficiency of a concentrating collector is defined as the ratio of the useful energy delivered to the energy incident at the concentrator aperture. This may be calculated from an energy balance on the receiver [7, 8] which is given by:

$$n = n_o - \left(\frac{U_L(T_r - T_a)}{I * CR}\right) \quad (1)$$

or in terms of the heat-removal factor:

$$n = F_R\left(n_o - \frac{U_L(T_i - T_a)}{I * CR}\right) \quad (2)$$

From both equations, it can be concluded that the efficiency of a concentrating collector depends on the optical efficiency (no) which is determined by the optical properties of the various materials used in the construction of the collector and the magnitude of the heat losses, as indicated by the second term in Eq. 1.

The advantage of concentrating collectors is that the heat losses are inversely proportional to the concentration ratio (CR). The standard collector-performance can be indicated by the corresponding straight line, whose slope and intercept are then indications of performance as shown in Eq. 3:

$$n = I_n - S\left(\frac{\Delta T}{I}\right) \quad (3)$$

Where In = Intercept = FR no and S = slope = 〖F〗_R U_L/CR and I is Solar beam radiation (W/m2).

The same relations apply to a flat plate-collector, in which case CR=1. The small heat-loss term in Eq. 1 and Eq. 2 for the parabolic trough collector leads to a small slope of the typical collector–performance curve, Fig. 1: this does not apply for flat-plate collectors. This means that the efficiency in the PTCs remains high at high inlet-water temperatures. Therefore, at a temperature of 100°C, which occurs at a ΔT/I value of about 0.1, PTCs work at an efficiency of about 62%, CPCs at about 32% and the FPC at about 10%. This clearly suggests that the PTC is the best type of collector for this application.

b) Parabolic-Trough Collector Design

Parabolic trough collectors are employed in a variety of applications, including industrial steam production [9] and hot-water production [10].

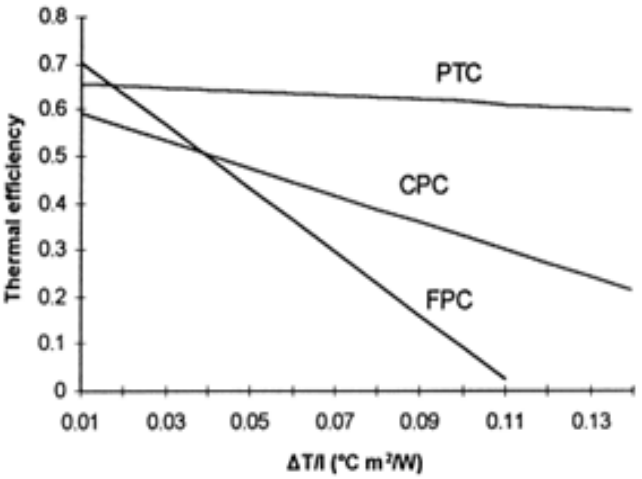


Fig. 1 : Typical collector–performance curves

Fig.2. Shows schematic of a parabolic trough collector these are preferred for solar steam-generation because, as was seen above, high temperatures can be obtained without any serious degradation of the collector efficiency. In this paper, PTCs are used for purified-water production by producing the steam used to power a MEB evaporator.

specifications of the collector are shown in Table 1. The same collector characteristics are applicable to all the collector sizes employed.

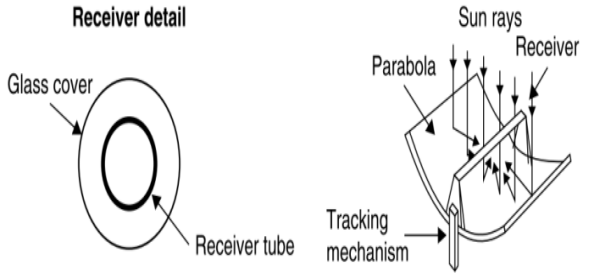


Fig. 2 : Schematic of a parabolic trough collect

Table 1 : Parabolic-trough collector specifications

Item	Value or type
Collector's aperture-area	10–2160 m^2
Collector' aperture	1.46 m
Aperture-to-length ratio	0.64
Rim angle	90°
Glass-to-receiver ratio	2.17
Receiver diameter	22 mm
Concentration ratio	21.2
Collector's intercept factor	0.95
Collector's test intercept	0.638
Collector's test slope	0.387 W/m^2K
Tracking-mechanism controller type	Electronic
Mode of tracking	E–W horizontal
Mass flow rate	0.012 kg/s m^2

III. Design of the Steam-Generation Method

Three methods have been employed to generate steam using parabolic-trough collectors:

i. The direct or in-situ concept in which two-phase flow is allowed in the collector receiver, so that steam is generated directly.
ii. The steam-flash concept, in which pressurized water is heated in the collector and then flashed to steam in a separate vessel.
iii. The unfired-boiler concept, in which a heat-transfer fluid is circulated through the collector and hence steam is generated via heat-exchange in an unfired boiler.

These steam-generation methods were analyzed with respect to the system's simplicity, capital-cost and stability [13].

It can be said that water-based systems are simpler and safer for desalination. With proper selection of flow rate and the desalination-system's steam-supply pressure, the pump power can be kept to a minimum. This reduces the main disadvantage of the steam-flash system against the in-situ system: as their costs are similar, the steam-flash system is selected. For a maximum value of solar radiation of 1000 W/m2, the outlet temperature of the water, for a 100°C inlet temperature (i.e. the pressure in the separator being equal to atmospheric and the flow-rate equal to 0.012 kg/s m2) would be 120°C. This is considered a reasonable value, not causing the collector to work at excessively high temperatures, and only requires a pressure of 2 bar to avoid boiling.

a) Flash-Vessel Design

In order to separate steam at a lower pressure, a flash vessel is used. This is a vertical vessel as shown in Fig. 3, with the inlet for the water located about one third of the way up its side. The standard design of flash vessels requires that the diameter of the vessel is chosen so that the steam flows towards the top outlet connection at no more than about 3 m/s. This should ensure that any water droplets can fall through the steam (i.e. in contra-flow), to the bottom of the vessel. Adequate height above the inlet is necessary to ensure separation. The separation is also facilitated by having the inlet projecting downwards into the vessel. The water-outlet connection is sized to minimize the pressure drop from the vessel to the pump inlet to avoid cavitation. The flash valve connected to the vessel inlet is spring loaded for adjustment purposes.

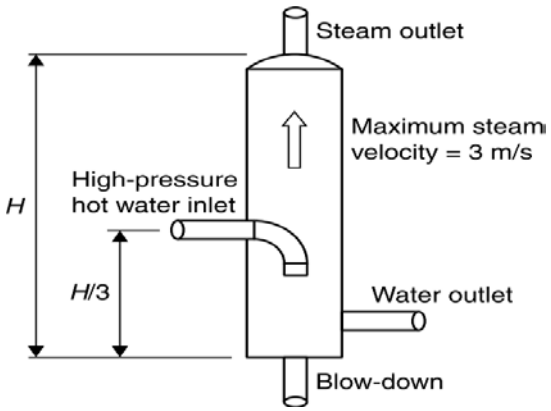


Fig. 3 : Flash vessel schematic diagram

In order to maximize the system's steam production, the heat-up energy requirements should be kept to a minimum. This is because energy invested in the preheating of the flash vessel is inevitably lost due to the nature of the diurnal cycle. The losses during overnight or shut-down return the vessel to near ambient conditions every morning. This could be readily achieved by optimizing the flash-vessel's water inventory and dimensions in order to lower the system's thermal capacity and losses. The following constraints on the optimization should be noted, however:

The mass of the circulating water contained in the pipes cannot be changed.

The water inventory in the flash vessel should not be reduced below a certain level, because the system's performance will deteriorate. The addition of make-up water, which is continuously supplied to keep

the water level in the flash vessel constant, would then "dilute" the system temperature and possibly result in instabilities [14].

The height of the flash vessel should also be kept to a minimum, which in combination with the right steam velocity would avoid the possibility of "contamination" of the steam with water droplets (i.e. carry-over). Furthermore, a reduced vessel height and hence a consequent reduction in the system's thermal capacity, will lead to a faster response of the system. In an earlier report [15], the problem of system optimization through variation of the flash-vessel's design was studied in detail. The optimal flash vessel design parameters for a system with a collector area of 10 m2 are shown in Fig. 3.

IV. Design of the Desalination System

a) System Circuit Arrangement

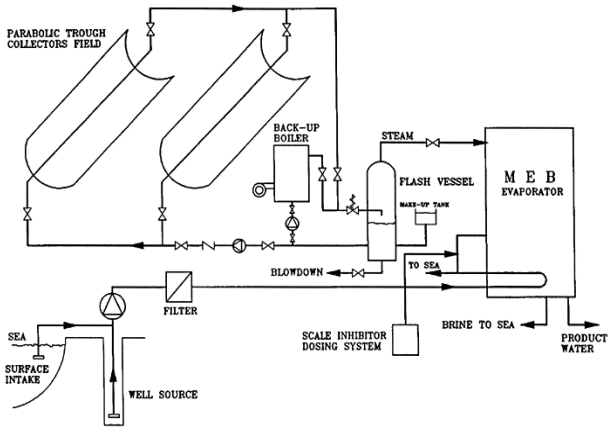


Fig. 4 : System circuit arrangement

The circuit must be able to carry the sea-water from the sea to the MEB evaporator and return the rejected brine back to the sea. These two streams must be remote from each other to avoid potential mixing problems. The circuit diagram, shown in Fig. 4, gives details of only the intake stream. Whenever possible, the intake from a well next to the coast line is preferred because as the water passes through the sand it is filtered. The water, after passing through a filter is directed to the MEB evaporator's last effect, to cool the steam produced in the previous effect. Part of this water is then returned to the sea as warm brine and part as feed water directed to the evaporator's top effect after a scale inhibitor is ejected. In Fig. 4, the solar collectors and the steam-generation system-piping layout is also shown. A back-up boiler is also shown in Fig. 4. This is necessary for the operation of the evaporator during days of low insulation and/or during the night. As can be seen from Fig. 4 no complicated controllers are required. This is because the steam delivery temperature is constant (i.e. dependent on the evaporator pressure) and the operation of the boiler can be controlled by a simple thermostat located at the pipe before the flash vessel. The same principle applies for the operation of the boiler during day-time (back-up of the solar system) and night-time.

b) Evaporator Design

Of the various types of MEB evaporators, the Multiple Effect Stack (MES) type is the most appropriate for solar-energy application. This features several advantages, the most important of which is the stable operation between virtually zero and 100% output, even when sudden changes are made, as well as its ability to follow a varying steam supply without upset. In Fig. 5, a four-effect MES evaporator is shown. Sea-water is sprayed into the top of the evaporator and descends as a thin film over the horizontally arranged tube-bundle in each effect.

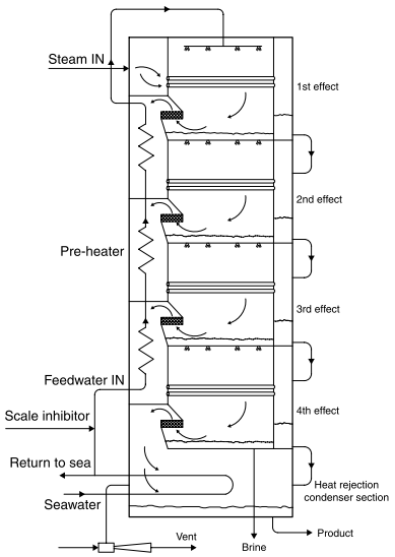


Fig. 5 : Four-effect MES evaporator

In the top (hottest) effect, steam from the solar-collector system condenses inside the tubes. Because of the low pressure created in the plant by the vent ejector system, the thin sea-water film boils on the outside of the tubes, so creating new vapor at a lower temperature than the condensing steam.

The sea-water falling to the floor of the first effect is cooled by flashing through nozzles into the second effect, which is at a lower pressure. The vapor made in the first effect is ducted into the inside of the tubes in the second effect, where it condenses to form part of the product. Again, the condensing warm vapor causes the cooler external sea-water film to boil at the reduced pressure.

The evaporation–condensation process is repeated from effect-to-effect down the plant, creating an almost equal amount of product inside the tubes of each effect. The vapor made in the last effect is condensed on the outside of a tube bundle cooled by raw sea-water. Most of the warmer sea-water is then returned to the sea, and a small part is used as feed

water to the plant. After being treated with acid to destroy scale-forming compounds, the feed water passes up the stack through a series of pre-heaters that use a little of the vapor from each effect to gradually raise its temperature, before it is sprayed into the top of the plant. The water produced from each effect is flashed in cascade down the plant so that it can be withdrawn in a cool condition at the bottom of the stack. The concentrated brine is also withdrawn at the bottom of the stack.

The MES process is completely stable in operation and automatically adjusts to changing steam conditions, even if they are suddenly applied, so it is suitable for load-following applications. It is a once-through process that minimizes the risk of scale formation without incurring a large chemical-scale dosing cost. The typical product purity is less than 5 ppm TDS and does not deteriorate as the plant ages. Therefore, the MEB process and in particular the MES-type evaporator appears to be the most suitable to be used with solar energy.

V. System Modeling

The modeling program is used to predict the quantity of the steam produced by the collector and the flash vessel, and subsequently the amount of desalinated water produced by the various systems. The principle of operation of the program is that it employs the values of the solar radiation and ambient-air temperature from a reference year developed previously. The values of the solar radiation are corrected hourly for the collector's inclination.

In the analysis, a representative day for each month is taken as shown in Table 2. These are chosen because the value of extraterrestrial solar-radiation is closest to the month's average for that day [17].

In the program, the actual measured collector performance parameters of test slope and intercept are required. These were obtained by testing the collector according to the procedures outlined in ASHRAE Standard 93[18].

Table 2 : Average day of each month

Month	Day	Month	Day
January	17	July	17
February	16	August	16
March	16	September	15
April	15	October	15
May	15	November	14
June	11	December	10

The program takes into account, in addition to the sensible heat and the thermal capacity of all the system components, all the heat losses from the system i.e. the flash-vessel body, pipes and pump body. After all these losses are estimated, the flash-vessel's inlet water temperature is determined. From the difference in enthalpy of this hot water from that of the water contained in the flash vessel, i.e. the steam production is calculated. The accuracy of the simulation depends to a great extent on the validity of the reference year. This was investigated when modeling the performance for hot water production from PTCs [19]

Table 3 : The modeled performances of the systems

Month	System production (litres/month)			
	Area=10 m^2	Area=60 m^2	Area=540 m^2	Area=2160 m^2
January	31	153	2488	11 197
February	56	341	4672	20 010
March	176	1237	11 452	59 331
April	250	1788	20 503	82 944
May	327	2335	26 510	107 205
June	481	3514	39 113	157 671
July	517	3795	42 139	169 672
August	456	3370	37 493	151 165
September	355	2635	29 497	119 051
October	194	1429	16 453	66 770
November	83	566	7096	29 238
December	39	233	3376	15 541

Although the variation reported was 7%, this cannot be generalized as an expected variation. Details about the structure of the program and the validation of the model are given in Kalogirou et al. [20]. The rate of fresh water produced by the desalination system is evaluated by using the evaporator performance ratio figure. Several systems were considered in this study with aperture areas varying from small 10m2 to large 2160m2. The smallest system is suitable for supplying water in a block of 3–4 houses and the largest for a village of about 400 persons. The modeled performances of the systems are shown in Table 3.

By studying Table 3, it can be seen that the system's performance is in phase with the weather, i.e. during periods of dry weather (summer) the system's production is at its greatest. This is considered to be the most important advantage of solar desalination.

VI. Optimization of the Rim Angle

The rim angle (ø_r) is the angle from the rim of the collector to the line normal to the collector surface passing through the focus. Fig. 6 shows that, for the same aperture, various rim angles are possible. It also shows that, for different rim angles, the focus-to-aperture ratio which defines the curvature of the parabola is changing. It can be demonstrated that, with a 90 ° rim angle, the mean focus to reflector distance and hence the reflected beam spread is minimized, so that the slope and tracking errors are less pronounced. [7] The collector's surface area decreases as the rim angle is decreased. There is a temptation to use smaller rim angles because there is only a small sacrifice in optical the cost of the reduction in the performance with

the small decrease in optical efficiency is greater than the saving in material area. the rim angle was finally selected to be 90 °.

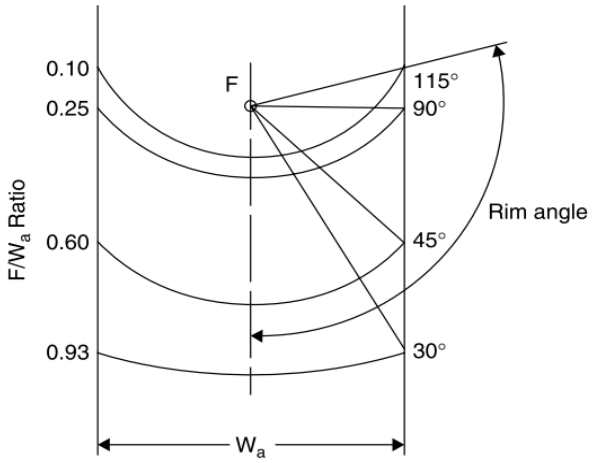


Fig. 6 : Rim Angle

VII. Selection of the Receiver Diameter

The receiver diameter determines the intercept factor and consequently the optical efficiency. The intercept factor is the ratio of the energy intercepted by the receiver to the total energy reflected by the focusing device [5]. Its value depends on the size of the receiver, the surface angle errors of the parabolic mirror, and the solar beam spread. These errors are identified as apparent changes of the Sun's width, scattering effects associated with the reflective surface, and scattering effects caused by random slope-errors (i.e. distortion of the parabola due to wind loading). Non-random errors account for the errors in the manufacture/assembly and/or in the operation of the collector. These are identified as reflected profile errors, misalignment errors and receiver location errors [8]. Random errors are modeled statistically, by total reflected-energy distribution standard deviations at normal incidence [8].

$$\sigma = \sqrt{\sigma^2_{sun} + 4\sigma^2_{slope} + \sigma^2_{mirror}} \qquad (6)$$

Non-random errors are determined by the misalignment angle error β (i.e. the angle between the reflected ray from the centre of the Sun and the normal to the reflector's aperture plane) and the receiver mislocation distance dr. As reflector profile errors and receiver mislocation along the Y-axis essentially have the same effect, this parameter is used to account for both. According to Guven and Bannerot,[8] random and non-random errors can be combined with the collector's geometric parameters, concentration ratio (CR) and receiver diameter (D), to yield error parameters universal to all collector geometries. These are called 'universal error parameters' and an asterisk is used to distinguish them from the already-defined parameters. Using the universal error parameters, the formulation of the intercept factor γ is possible from eq. 6. [9].

$$\gamma = \frac{1+\cos\phi_r}{2\sin\phi_r}\int_0^{\phi_r}\left[\mathrm{Erf}\left(\frac{\sin\phi_r(1+\cos\phi)(1-2d^*\sin\phi)-\pi\beta^*(1+\cos\phi_r)}{\sqrt{2}\pi\sigma^*(1-\cos\phi_r)}\right)\right.$$
$$\left.-\mathrm{Erf}\left(-\frac{\sin\phi_r(1+\cos\phi)(1+2d^*\sin\phi)+\pi\beta^*(1+\cos\phi_r)}{\sqrt{2}\pi\sigma^*(1-\cos\phi_r)}\right)\right]\frac{d\phi}{(1+\cos\phi)} \qquad (6)$$

Table 4 : Intercept Factors for Various Receiver Diameters

Receiver diameter (mm)	*CR*	*Intercept factor*
6	42·44	0·80
9	28·29	0·94
12	21·22	0·98
15	16·98	0·99
18	14·15	1·00
21	12·13	1·00

For the evaluation of the intercept factor, a computer program was written. The principle of operation of the program is that the two error functions within the integral are estimated for each step of angle φ and then the integral is numerically evaluated using Simpson's integration method.

For a carefully-fabricated collector, [8] mirror=0.002 rad and σslope=0.004 rad. The standard distribution of the Sun's intensity-distribution can be taken as 0.0025 rad. Therefore σ (in radians) is given by:

$$\sigma = \sqrt{(0.0025)^2 + 4(0.004)^2 + (0.002)^2} = 0.00861$$

β = 0.2° = 0.0035 rad (i.e. the maximum tracking error), [8].

Using these inputs, together with various receiver diameters, the results shown in Table 4 were obtained. Certainly the aim is towards a high intercept factor. From Table 4 the selection of the receiver diameter could be either 12 or 15 mm. The final selection would depend, however, on the thermal analysis. This is because the larger diameter gives a higher intercept factor but simultaneously higher thermal losses. The results of the thermal analysis are shown in Table 5, it can be seen that the thermal efficiency is a maximum for the 12 mm-diameter receiver, which is naturally selected.

Table 5 : Thermal Efficiency as a Function of Receiver Diameter

Receiver diameter (mm)	*Optical efficiency*	*Thermal efficiency*
6	0·529	0·496
9	0·618	0·568
12	0·648	0·582
15	0·661	0·579
18	0·661	0·562
21	0·661	0·545

VIII. Tracking

Fig. 7 shows the system, which was designed to operate with the required tracking accuracy, consists of a small direct current motor that rotates the collector via a speed reduction gearbox. A diagram of the system, together with a table showing the functions of the control system, is presented in Fig. 7. The system employs three sensors, of which A is installed on the east side of the collector shaded by the frame, whereas the other two (B and C) are installed on the collector frame. Sensor A acts as the "focus" sensor, i.e., it receives direct sunlight only when the collector is focused. As the sun moves, sensor A becomes shaded and the motor turns "on." Sensor B is the "cloud" sensor, and cloud cover is assumed when illumination falls below a certain level. Sensor C is the "daylight" sensor. The condition when all three sensors receive sunlight is translated by the control system as daytime with no cloud passing over the sun and the collector in a focused position. The functions shown in the table of Fig.7 are followed provided that sensor C is "on," i.e., it is daytime. The sensors used are light-dependent resistors (LDRs).The main disadvantage of LDRs is that they cannot distinguish between direct and diffuse sunlight. However, this can be overcome by adding an adjustable resistor to the system, which can be set for direct sunlight (i.e., a threshold value). This is achieved by setting the adjustable resistor so that for direct sunlight, the appropriate input logic level (i.e., 0) is set.

As mentioned previously, the motor of the system is switched on when any of the three LDRs is shaded. Which sensor is activated depends on the amount of shading determined by the value set on the adjustable resistor, i.e., threshold value of radiation required to trigger the relays. Sensor A is always partially shaded. As the shading increases due to the movement of the sun, a value is reached that triggers the forward relay, which switches the motor on to turn the collector and therefore re-exposes sensor A. The system also accommodates cloud cover, i.e., when sensor B is not receiving direct sunlight, determined by the value of another adjustable resistor, a timer is automatically connected to the system and this powers the motor every 2 min for about 7s. As a result, the collector follows approximately the sun's path and when the sun reappears the collector is re-focused by the function of sensor A.

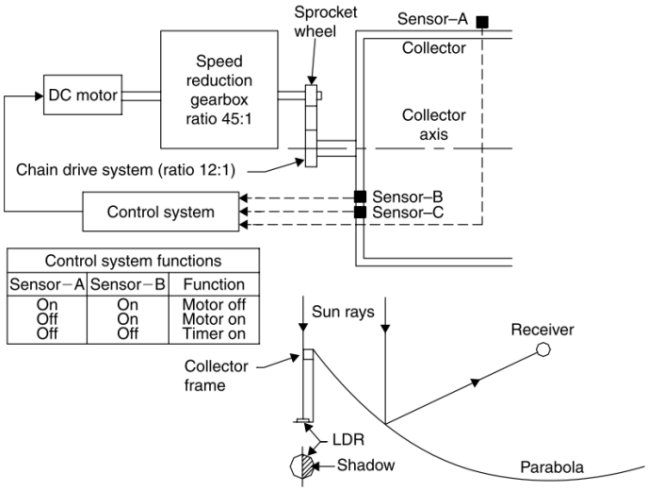


Fig. 7 : PTC with tracking system

The system also incorporates two limit switches, the function of which is to stop the motor from going beyond the rotational limits. These are installed on two stops, which restrict the overall rotation of the collector in both directions, east and west. The collector tracks to the west as long as it is daytime. When the sun goes down and sensor C determines that it is night, power is connected to a reverse relay, which changes the motor's polarity and rotates the collector until its motion is restricted by the east limit switch. If there is no sun during the following morning, the timer is used to follow the sun's path as under normal cloudy conditions. The tracking system just described, comprising an electric motor and a gearbox, is for small collectors. For large collectors, powerful hydraulic units are required.

IX. Conclusions

Solar desalination can be viable for the two bigger installations considered. The unit water cost is insensitive to changes in the method of payment or to variations in direct costs. However, it is not usually worth operating the desalination system solely on solar energy due to the high cost of the desalination system and the high percentage of inactive time.

The author believes that even in cases where the fuel only systems result in lower or equal water prices compared with a solar-plus-fuel system, the solar alternative should not be abandoned because as it was proven a possible increase in fuel price turns the system viability in favor of the solar system. The issues of global warming and climate change resulting from the increase in greenhouse gases due to the burning of fuels should not be underestimated.

The design of a PTC system has been accomplished by performing an optimization of the collector's aperture and rim angle and the selection of the receiver's diameter. The last parameter was selected by examining the various errors encountered in the manufacture and/or operation of the system.

References Références Referencias

1. Malik MAS, Tiwari GN, Kumar A, Sodha MS. Solar distillation. Oxford: Pergamon Press, 1985.
2. Meinel AB, Meinel MP. Applied solar energy—an introduction. Reading, MA: Addison–Wesley, 1976.
3. Marinos D, Assimacopoulos D, Provatas F. The experience of local authorities with water desalination in the Islands of Southern Europe. Proceedings of the New Technologies for the Use of Renewable Energy Sources in Water Desalination, Athens, Greece, Section V, 1991, pp 48–56.
4. Morris RM, Hanbury WT. Renewable energy and desalination—a review. Proceedings of the New Technologies for the Use of Renewable Energy Sources in Water Desalination, Athens, Greece, Section I, 1991, pp 30–50.
5. Zarza E, Ajona, JI, Leon J, Genthner K, Gregorzewski A. Solar thermal desalination project at the Plataforma Solar De Almeria. Proceedings of the Biennial Congress of the International Solar Energy Society, Denver, CO, Vol. 1, Part II, 1991, pp 2270–2275.
6. Porteous A. Saline water distillation processes. Barking, UK: Longman, 1975.
7. Duffie JA, Beckman WA. Solar engineering of thermal processes. 2nd ed. New York: John Wiley & Sons, 1991.
8. Guven, H. M. & Bannerot, R. B., Determination of error tolerances for the optical design of parabolic troughs for developing countries. solar Energy, 36(6) (1986), pp 535-50.
9. Guven, H. M. & Bannerot, R. B., Derivation of universal error parameters for comprehensive optical analysis of parabolic troughs. Proceedings of the ASME-ASESSolar Energy Conference, Knoxville, 1985, pp. 168-74.
10. Kreith F, Kreider JF. Principles of solar engineering. New York: McGraw–Hill, 1985.
11. Murphy LM, May KE. Steam generation in line-focus solar collectors: a comparative assessment of thermal performance, operating stability, and cost issues. SERI/TR-1311, 1982.
12. S. Lloyd, Use of solar parabolic trough collectors for hot water production in Cyprus feasibility study. Renewable Energy Journal (1992), pp. 117–124.
13. P Eleftheriou, S. Lloyd, S Kalogirou, and J. Ward, Design and performance characteristics of a parabolic-trough solar-collector system. Applied Energy 47 1994, pp. 341–354.
14. Kalogirou S. Parabolic-trough collector system for low temperature steam generation-design and performance characteristics. Applied Energy, 1996; pp 1–19.
15. Hurtado P, Kast M. Experimental study of direct in-situ generation line focus solar collector. SERI, 1984.
16. Peterson PJ, Keneth E. Flow instability during direct steam generation in a line-focus solar collector system. SERI/TR-1354.
17. Kalogirou S, Eleftheriou P, Lloyd S, Ward J. Optimization of the initial response of a solar steam generation plant. Proceedings of the 1995 ASME/JSME/JSES International Solar Energy Conference, Maui, HI, 1995, pp513–520.
18. A Meaburn and FM. Hughes, A simple predictive controller for use on large scale arrays of parabolic trough collectors. Solar Energy 1996, pp. 583–595.
19. ASHRAE Standard 93-1986. Methods of testing to determine the thermal performance of solar collectors. ANSI/ASHRAE 93, 1986.
20. Kalogirou S, Lloyd S, Ward J. Modeling of a parabolic trough collector system for hot-water production. Proceedings of the ISES Solar World Congress, Budapest, Hungary 1993; pp 145–150.

Nomenclature

PTC	Parabolic-trough collector
FPC	Flat plate collector
CPC	Compound parabolic-collector
ER-RO	Energy recovery-reverse osmosis
MEB	Multiple-effect boiling (evaporator)
MES	Multiple-effect stack (evaporator)
MSF	Multiple-effect flash (evaporator)
RO	Reverse osmosis
ppm	Parts per million
VC	Vapor compression
PR	Performance ratio
CR	Concentration ratio
F_R	Heat removal factor
I	Beam solar radiation (W/m^2)
I_n	Test intercept of collector performance graph
N	Number of years
n_o	Optical efficiency
n	Thermal efficiency
S	Test slope of the collector's performance graph
T_a	Ambient temperature (K)
T_i	Collector's inlet temperature (K)
T_r	Mean receiver temperature (K)
U_L	Steady-state heat loss coefficient (W/m^{2}K)
DT	Temperature difference, $(T_i - T_a)$ (K)

Global Journals Inc. (US) Guidelines Handbook 2013

www.GlobalJournals.org

FELLOW OF ASSOCIATION OF RESEARCH SOCIETY IN ENGINEERING (FARSE)

- 'FARSE' title will be awarded to the person after approval of Editor-in-Chief and Editorial Board. The title 'FARSE" can be added to name in the following manner. eg. Dr. John E. Hall, Ph.D., FARSE or William Walldroff Ph. D., M.S., FARSE
- Being FARSE is a respectful honor. It authenticates your research activities. After becoming FARSE, you can use 'FARSE' title as you use your degree in suffix of your name. This will definitely will enhance and add up your name. You can use it on your Career Counseling Materials/CV/Resume/Visiting Card/Name Plate etc.
- 60% Discount will be provided to FARSE members for publishing research papers in Global Journals Inc., if our Editorial Board and Peer Reviewers accept the paper. For the life time, if you are author/co-author of any paper bill sent to you will automatically be discounted one by 60%
- FARSE will be given a renowned, secure, free professional email address with 100 GB of space eg.johnhall@globaljournals.org. You will be facilitated with Webmail, Spam Assassin, Email Forwarders, Auto-Responders, Email Delivery Route tracing, etc.
- FARSE member is eligible to become paid peer reviewer at Global Journals Inc. to earn up to 15% of realized author charges taken from author of respective paper. After reviewing 5 or more papers you can request to transfer the amount to your bank account or to your PayPal account.
- Eg. If we had taken 420 USD from author, we can send 63 USD to your account.
- FARSE member can apply for free approval, grading and certification of some of their Educational and Institutional Degrees from Global Journals Inc. (US) and Open Association of Research, Society U.S.A.
- After you are FARSE. You can send us scanned copy of all of your documents. We will verify, grade and certify them within a month. It will be based on your academic records, quality of research papers published by you, and 50 more criteria. This is beneficial for your job interviews as recruiting organization need not just rely on you for authenticity and your unknown qualities, you would have authentic ranks of all of your documents. Our scale is unique worldwide.
- FARSE member can proceed to get benefits of free research podcasting in Global Research Radio with their research documents, slides and online movies.
- After your publication anywhere in the world, you can upload you research paper with your recorded voice or you can use our professional RJs to record your paper their voice. We can also stream your conference videos and display your slides online.
- FARSE will be eligible for free application of Standardization of their Researches by Open Scientific Standards. Standardization is next step and level after publishing in a journal. A team of research and professional will work with you to take your research to its next level, which is worldwide open standardization.

- FARSE is eligible to earn from their researches: While publishing his paper with Global Journals Inc. (US), FARSE can decide whether he/she would like to publish his/her research in closed manner. When readers will buy that individual research paper for reading, 80% of its earning by Global Journals Inc. (US) will be transferred to FARSE member's bank account after certain threshold balance. There is no time limit for collection. FARSE member can decide its price and we can help in decision.

MEMBER OF ASSOCIATION OF RESEARCH SOCIETY IN ENGINEERING (MARSE)

- 'MARSE' title will be awarded to the person after approval of Editor-in-Chief and Editorial Board. The title 'MARSE" can be added to name in the following manner. eg. Dr. John E. Hall, Ph.D., MARSE or William Walldroff Ph. D., M.S., MARSE
- Being MARSE is a respectful honor. It authenticates your research activities. After becoming MARSE, you can use 'MARSE' title as you use your degree in suffix of your name. This will definitely will enhance and add up your name. You can use it on your Career Counseling Materials/CV/Resume/Visiting Card/Name Plate etc.
- 40% Discount will be provided to MARSE members for publishing research papers in Global Journals Inc., if our Editorial Board and Peer Reviewers accept the paper. For the life time, if you are author/co-author of any paper bill sent to you will automatically be discounted one by 60%
- MARSE will be given a renowned, secure, free professional email address with 30 GB of space eg.johnhall@globaljournals.org. You will be facilitated with Webmail, SpamAssassin, Email Forwarders, Auto-Responders, Email Delivery Route tracing, etc.
- MARSE member is eligible to become paid peer reviewer at Global Journals Inc. to earn up to 10% of realized author charges taken from author of respective paper. After reviewing 5 or more papers you can request to transfer the amount to your bank account or to your PayPal account.
- MARSE member can apply for free approval, grading and certification of some of their Educational and Institutional Degrees from Global Journals Inc. (US) and Open Association of Research,Society U.S.A.
- MARSE is eligible to earn from their researches: While publishing his paper with Global Journals Inc. (US), MARSE can decide whether he/she would like to publish his/her research in closed manner. When readers will buy that individual research paper for reading, 40% of its earning by Global Journals Inc. (US) will be transferred to MARSE member's bank account after certain threshold balance. There is no time limit for collection. MARSE member can decide its price and we can help in decision.

AUXILIARY MEMBERSHIPS

ANNUAL MEMBER

- Annual Member will be authorized to receive e-Journal GJRE for one year (subscription for one year).
- The member will be allotted free 1 GB Web-space along with subDomain to contribute and participate in our activities.
- A professional email address will be allotted free 500 MB email space.

PAPER PUBLICATION

- The members can publish paper once. The paper will be sent to two-peer reviewer. The paper will be published after the acceptance of peer reviewers and Editorial Board.

Process of submission of Research Paper

The Area or field of specialization may or may not be of any category as mentioned in 'Scope of Journal' menu of the GlobalJournals.org website. There are 37 Research Journal categorized with Six parental Journals GJCST, GJMR, GJRE, GJMBR, GJSFR, GJHSS. For Authors should prefer the mentioned categories. There are three widely used systems UDC, DDC and LCC. The details are available as 'Knowledge Abstract' at Home page. The major advantage of this coding is that, the research work will be exposed to and shared with all over the world as we are being abstracted and indexed worldwide.

The paper should be in proper format. The format can be downloaded from first page of 'Author Guideline' Menu. The Author is expected to follow the general rules as mentioned in this menu. The paper should be written in MS-Word Format (*.DOC,*.DOCX).

The Author can submit the paper either online or offline. The authors should prefer online submission.Online Submission: There are three ways to submit your paper:

(A) (I) First, register yourself using top right corner of Home page then Login. If you are already registered, then login using your username and password.

(II) Choose corresponding Journal.

(III) Click 'Submit Manuscript'. Fill required information and Upload the paper.

(B) If you are using Internet Explorer, then Direct Submission through Homepage is also available.

(C) If these two are not conveninet , and then email the paper directly to dean@globaljournals.org.

Offline Submission: Author can send the typed form of paper by Post. However, online submission should be preferred.

Preferred Author Guidelines

MANUSCRIPT STYLE INSTRUCTION (Must be strictly followed)

Page Size: 8.27" X 11'"

- Left Margin: 0.65
- Right Margin: 0.65
- Top Margin: 0.75
- Bottom Margin: 0.75
- Font type of all text should be Swis 721 Lt BT.
- Paper Title should be of Font Size 24 with one Column section.
- Author Name in Font Size of 11 with one column as of Title.
- Abstract Font size of 9 Bold, "Abstract" word in Italic Bold.
- Main Text: Font size 10 with justified two columns section
- Two Column with Equal Column with of 3.38 and Gaping of .2
- First Character must be three lines Drop capped.
- Paragraph before Spacing of 1 pt and After of 0 pt.
- Line Spacing of 1 pt
- Large Images must be in One Column
- Numbering of First Main Headings (Heading 1) must be in Roman Letters, Capital Letter, and Font Size of 10.
- Numbering of Second Main Headings (Heading 2) must be in Alphabets, Italic, and Font Size of 10.

You can use your own standard format also.
Author Guidelines:

1. General,

2. Ethical Guidelines,

3. Submission of Manuscripts,

4. Manuscript's Category,

5. Structure and Format of Manuscript,

6. After Acceptance.

1. GENERAL

Before submitting your research paper, one is advised to go through the details as mentioned in following heads. It will be beneficial, while peer reviewer justify your paper for publication.

Scope

The Global Journals Inc. (US) welcome the submission of original paper, review paper, survey article relevant to the all the streams of Philosophy and knowledge. The Global Journals Inc. (US) is parental platform for Global Journal of Computer Science and Technology, Researches in Engineering, Medical Research, Science Frontier Research, Human Social Science, Management, and Business organization. The choice of specific field can be done otherwise as following in Abstracting and Indexing Page on this Website. As the all Global

Journals Inc. (US) are being abstracted and indexed (in process) by most of the reputed organizations. Topics of only narrow interest will not be accepted unless they have wider potential or consequences.

2. ETHICAL GUIDELINES

Authors should follow the ethical guidelines as mentioned below for publication of research paper and research activities.

Papers are accepted on strict understanding that the material in whole or in part has not been, nor is being, considered for publication elsewhere. If the paper once accepted by Global Journals Inc. (US) and Editorial Board, will become the copyright of the Global Journals Inc. (US).

Authorship: The authors and coauthors should have active contribution to conception design, analysis and interpretation of findings. They should critically review the contents and drafting of the paper. All should approve the final version of the paper before submission

The Global Journals Inc. (US) follows the definition of authorship set up by the Global Academy of Research and Development. According to the Global Academy of R&D authorship, criteria must be based on:

1) Substantial contributions to conception and acquisition of data, analysis and interpretation of the findings.

2) Drafting the paper and revising it critically regarding important academic content.

3) Final approval of the version of the paper to be published.

All authors should have been credited according to their appropriate contribution in research activity and preparing paper. Contributors who do not match the criteria as authors may be mentioned under Acknowledgement.

Acknowledgements: Contributors to the research other than authors credited should be mentioned under acknowledgement. The specifications of the source of funding for the research if appropriate can be included. Suppliers of resources may be mentioned along with address.

Appeal of Decision: The Editorial Board's decision on publication of the paper is final and cannot be appealed elsewhere.

Permissions: It is the author's responsibility to have prior permission if all or parts of earlier published illustrations are used in this paper.

Please mention proper reference and appropriate acknowledgements wherever expected.

If all or parts of previously published illustrations are used, permission must be taken from the copyright holder concerned. It is the author's responsibility to take these in writing.

Approval for reproduction/modification of any information (including figures and tables) published elsewhere must be obtained by the authors/copyright holders before submission of the manuscript. Contributors (Authors) are responsible for any copyright fee involved.

3. SUBMISSION OF MANUSCRIPTS

Manuscripts should be uploaded via this online submission page. The online submission is most efficient method for submission of papers, as it enables rapid distribution of manuscripts and consequently speeds up the review procedure. It also enables authors to know the status of their own manuscripts by emailing us. Complete instructions for submitting a paper is available below.

Manuscript submission is a systematic procedure and little preparation is required beyond having all parts of your manuscript in a given format and a computer with an Internet connection and a Web browser. Full help and instructions are provided on-screen. As an author, you will be prompted for login and manuscript details as Field of Paper and then to upload your manuscript file(s) according to the instructions.

To avoid postal delays, all transaction is preferred by e-mail. A finished manuscript submission is confirmed by e-mail immediately and your paper enters the editorial process with no postal delays. When a conclusion is made about the publication of your paper by our Editorial Board, revisions can be submitted online with the same procedure, with an occasion to view and respond to all comments.

Complete support for both authors and co-author is provided.

4. MANUSCRIPT'S CATEGORY

Based on potential and nature, the manuscript can be categorized under the following heads:

Original research paper: Such papers are reports of high-level significant original research work.

Review papers: These are concise, significant but helpful and decisive topics for young researchers.

Research articles: These are handled with small investigation and applications

Research letters: The letters are small and concise comments on previously published matters.

5.STRUCTURE AND FORMAT OF MANUSCRIPT

The recommended size of original research paper is less than seven thousand words, review papers fewer than seven thousands words also.Preparation of research paper or how to write research paper, are major hurdle, while writing manuscript. The research articles and research letters should be fewer than three thousand words, the structure original research paper; sometime review paper should be as follows:

Papers: These are reports of significant research (typically less than 7000 words equivalent, including tables, figures, references), and comprise:

(a)Title should be relevant and commensurate with the theme of the paper.

(b) A brief Summary, "Abstract" (less than 150 words) containing the major results and conclusions.

(c) Up to ten keywords, that precisely identifies the paper's subject, purpose, and focus.

(d) An Introduction, giving necessary background excluding subheadings; objectives must be clearly declared.

(e) Resources and techniques with sufficient complete experimental details (wherever possible by reference) to permit repetition; sources of information must be given and numerical methods must be specified by reference, unless non-standard.

(f) Results should be presented concisely, by well-designed tables and/or figures; the same data may not be used in both; suitable statistical data should be given. All data must be obtained with attention to numerical detail in the planning stage. As reproduced design has been recognized to be important to experiments for a considerable time, the Editor has decided that any paper that appears not to have adequate numerical treatments of the data will be returned un-refereed;

(g) Discussion should cover the implications and consequences, not just recapitulating the results; conclusions should be summarizing.

(h) Brief Acknowledgements.

(i) References in the proper form.

Authors should very cautiously consider the preparation of papers to ensure that they communicate efficiently. Papers are much more likely to be accepted, if they are cautiously designed and laid out, contain few or no errors, are summarizing, and be conventional to the approach and instructions. They will in addition, be published with much less delays than those that require much technical and editorial correction.

The Editorial Board reserves the right to make literary corrections and to make suggestions to improve briefness.

It is vital, that authors take care in submitting a manuscript that is written in simple language and adheres to published guidelines.

Format

Language: The language of publication is UK English. Authors, for whom English is a second language, must have their manuscript efficiently edited by an English-speaking person before submission to make sure that, the English is of high excellence. It is preferable, that manuscripts should be professionally edited.

Standard Usage, Abbreviations, and Units: Spelling and hyphenation should be conventional to The Concise Oxford English Dictionary. Statistics and measurements should at all times be given in figures, e.g. 16 min, except for when the number begins a sentence. When the number does not refer to a unit of measurement it should be spelt in full unless, it is 160 or greater.

Abbreviations supposed to be used carefully. The abbreviated name or expression is supposed to be cited in full at first usage, followed by the conventional abbreviation in parentheses.

Metric SI units are supposed to generally be used excluding where they conflict with current practice or are confusing. For illustration, 1.4 l rather than 1.4 × 10-3 m3, or 4 mm somewhat than 4 × 10-3 m. Chemical formula and solutions must identify the form used, e.g. anhydrous or hydrated, and the concentration must be in clearly defined units. Common species names should be followed by underlines at the first mention. For following use the generic name should be constricted to a single letter, if it is clear.

Structure

All manuscripts submitted to Global Journals Inc. (US), ought to include:

Title: The title page must carry an instructive title that reflects the content, a running title (less than 45 characters together with spaces), names of the authors and co-authors, and the place(s) wherever the work was carried out. The full postal address in addition with the e-mail address of related author must be given. Up to eleven keywords or very brief phrases have to be given to help data retrieval, mining and indexing.

Abstract, used in Original Papers and Reviews:

Optimizing Abstract for Search Engines

Many researchers searching for information online will use search engines such as Google, Yahoo or similar. By optimizing your paper for search engines, you will amplify the chance of someone finding it. This in turn will make it more likely to be viewed and/or cited in a further work. Global Journals Inc. (US) have compiled these guidelines to facilitate you to maximize the web-friendliness of the most public part of your paper.

Key Words

A major linchpin in research work for the writing research paper is the keyword search, which one will employ to find both library and Internet resources.

One must be persistent and creative in using keywords. An effective keyword search requires a strategy and planning a list of possible keywords and phrases to try.

Search engines for most searches, use Boolean searching, which is somewhat different from Internet searches. The Boolean search uses "operators," words (and, or, not, and near) that enable you to expand or narrow your affords. Tips for research paper while preparing research paper are very helpful guideline of research paper.

Choice of key words is first tool of tips to write research paper. Research paper writing is an art.A few tips for deciding as strategically as possible about keyword search:

- One should start brainstorming lists of possible keywords before even begin searching. Think about the most important concepts related to research work. Ask, "What words would a source have to include to be truly valuable in research paper?" Then consider synonyms for the important words.
- It may take the discovery of only one relevant paper to let steer in the right keyword direction because in most databases, the keywords under which a research paper is abstracted are listed with the paper.
- One should avoid outdated words.

Keywords are the key that opens a door to research work sources. Keyword searching is an art in which researcher's skills are bound to improve with experience and time.

Numerical Methods: Numerical methods used should be clear and, where appropriate, supported by references.

Acknowledgements: Please make these as concise as possible.

References

References follow the Harvard scheme of referencing. References in the text should cite the authors' names followed by the time of their publication, unless there are three or more authors when simply the first author's name is quoted followed by et al. unpublished work has to only be cited where necessary, and only in the text. Copies of references in press in other journals have to be supplied with submitted typescripts. It is necessary that all citations and references be carefully checked before submission, as mistakes or omissions will cause delays.

References to information on the World Wide Web can be given, but only if the information is available without charge to readers on an official site. Wikipedia and Similar websites are not allowed where anyone can change the information. Authors will be asked to make available electronic copies of the cited information for inclusion on the Global Journals Inc. (US) homepage at the judgment of the Editorial Board.

The Editorial Board and Global Journals Inc. (US) recommend that, citation of online-published papers and other material should be done via a DOI (digital object identifier). If an author cites anything, which does not have a DOI, they run the risk of the cited material not being noticeable.

The Editorial Board and Global Journals Inc. (US) recommend the use of a tool such as Reference Manager for reference management and formatting.

Tables, Figures and Figure Legends

Tables: Tables should be few in number, cautiously designed, uncrowned, and include only essential data. Each must have an Arabic number, e.g. Table 4, a self-explanatory caption and be on a separate sheet. Vertical lines should not be used.

Figures: Figures are supposed to be submitted as separate files. Always take in a citation in the text for each figure using Arabic numbers, e.g. Fig. 4. Artwork must be submitted online in electronic form by e-mailing them.

Preparation of Electronic Figures for Publication

Even though low quality images are sufficient for review purposes, print publication requires high quality images to prevent the final product being blurred or fuzzy. Submit (or e-mail) EPS (line art) or TIFF (halftone/photographs) files only. MS PowerPoint and Word Graphics are unsuitable for printed pictures. Do not use pixel-oriented software. Scans (TIFF only) should have a resolution of at least 350 dpi (halftone) or 700 to 1100 dpi (line drawings) in relation to the imitation size. Please give the data for figures in black and white or submit a Color Work Agreement Form. EPS files must be saved with fonts embedded (and with a TIFF preview, if possible).

For scanned images, the scanning resolution (at final image size) ought to be as follows to ensure good reproduction: line art: >650 dpi; halftones (including gel photographs) : >350 dpi; figures containing both halftone and line images: >650 dpi.

Figure Legends: Self-explanatory legends of all figures should be incorporated separately under the heading 'Legends to Figures'. In the full-text online edition of the journal, figure legends may possibly be truncated in abbreviated links to the full screen version. Therefore, the first 100 characters of any legend should notify the reader, about the key aspects of the figure.

6. AFTER ACCEPTANCE

Upon approval of a paper for publication, the manuscript will be forwarded to the dean, who is responsible for the publication of the Global Journals Inc. (US).

6.1 Proof Corrections

The corresponding author will receive an e-mail alert containing a link to a website or will be attached. A working e-mail address must therefore be provided for the related author.

Acrobat Reader will be required in order to read this file. This software can be downloaded

(Free of charge) from the following website:

www.adobe.com/products/acrobat/readstep2.html. This will facilitate the file to be opened, read on screen, and printed out in order for any corrections to be added. Further instructions will be sent with the proof.

Proofs must be returned to the dean at dean@globaljournals.org within three days of receipt.

As changes to proofs are costly, we inquire that you only correct typesetting errors. All illustrations are retained by the publisher. Please note that the authors are responsible for all statements made in their work, including changes made by the copy editor.

6.2 Early View of Global Journals Inc. (US) (Publication Prior to Print)

The Global Journals Inc. (US) are enclosed by our publishing's Early View service. Early View articles are complete full-text articles sent in advance of their publication. Early View articles are absolute and final. They have been completely reviewed, revised and edited for publication, and the authors' final corrections have been incorporated. Because they are in final form, no changes can be made after sending them. The nature of Early View articles means that they do not yet have volume, issue or page numbers, so Early View articles cannot be cited in the conventional way.

6.3 Author Services

Online production tracking is available for your article through Author Services. Author Services enables authors to track their article - once it has been accepted - through the production process to publication online and in print. Authors can check the status of their articles online and choose to receive automated e-mails at key stages of production. The authors will receive an e-mail with a unique link that enables them to register and have their article automatically added to the system. Please ensure that a complete e-mail address is provided when submitting the manuscript.

6.4 Author Material Archive Policy

Please note that if not specifically requested, publisher will dispose off hardcopy & electronic information submitted, after the two months of publication. If you require the return of any information submitted, please inform the Editorial Board or dean as soon as possible.

6.5 Offprint and Extra Copies

A PDF offprint of the online-published article will be provided free of charge to the related author, and may be distributed according to the Publisher's terms and conditions. Additional paper offprint may be ordered by emailing us at: editor@globaljournals.org .

You must strictly follow above Author Guidelines before submitting your paper or else we will not at all be responsible for any corrections in future in any of the way.

Before start writing a good quality Computer Science Research Paper, let us first understand what is Computer Science Research Paper? So, Computer Science Research Paper is the paper which is written by professionals or scientists who are associated to Computer Science and Information Technology, or doing research study in these areas. If you are novel to this field then you can consult about this field from your supervisor or guide.

TECHNIQUES FOR WRITING A GOOD QUALITY RESEARCH PAPER:

1. Choosing the topic: In most cases, the topic is searched by the interest of author but it can be also suggested by the guides. You can have several topics and then you can judge that in which topic or subject you are finding yourself most comfortable. This can be done by asking several questions to yourself, like Will I be able to carry our search in this area? Will I find all necessary recourses to accomplish the search? Will I be able to find all information in this field area? If the answer of these types of questions will be "Yes" then you can choose that topic. In most of the cases, you may have to conduct the surveys and have to visit several places because this field is related to Computer Science and Information Technology. Also, you may have to do a lot of work to find all rise and falls regarding the various data of that subject. Sometimes, detailed information plays a vital role, instead of short information.

2. Evaluators are human: First thing to remember that evaluators are also human being. They are not only meant for rejecting a paper. They are here to evaluate your paper. So, present your Best.

3. Think Like Evaluators: If you are in a confusion or getting demotivated that your paper will be accepted by evaluators or not, then think and try to evaluate your paper like an Evaluator. Try to understand that what an evaluator wants in your research paper and automatically you will have your answer.

4. Make blueprints of paper: The outline is the plan or framework that will help you to arrange your thoughts. It will make your paper logical. But remember that all points of your outline must be related to the topic you have chosen.

5. Ask your Guides: If you are having any difficulty in your research, then do not hesitate to share your difficulty to your guide (if you have any). They will surely help you out and resolve your doubts. If you can't clarify what exactly you require for your work then ask the supervisor to help you with the alternative. He might also provide you the list of essential readings.

6. Use of computer is recommended: As you are doing research in the field of Computer Science, then this point is quite obvious.

7. Use right software: Always use good quality software packages. If you are not capable to judge good software then you can lose quality of your paper unknowingly. There are various software programs available to help you, which you can get through Internet.

8. Use the Internet for help: An excellent start for your paper can be by using the Google. It is an excellent search engine, where you can have your doubts resolved. You may also read some answers for the frequent question how to write my research paper or find model research paper. From the internet library you can download books. If you have all required books make important reading selecting and analyzing the specified information. Then put together research paper sketch out.

9. Use and get big pictures: Always use encyclopedias, Wikipedia to get pictures so that you can go into the depth.

10. Bookmarks are useful: When you read any book or magazine, you generally use bookmarks, right! It is a good habit, which helps to not to lose your continuity. You should always use bookmarks while searching on Internet also, which will make your search easier.

11. Revise what you wrote: When you write anything, always read it, summarize it and then finalize it.

12. Make all efforts: Make all efforts to mention what you are going to write in your paper. That means always have a good start. Try to mention everything in introduction, that what is the need of a particular research paper. Polish your work by good skill of writing and always give an evaluator, what he wants.

13. Have backups: When you are going to do any important thing like making research paper, you should always have backup copies of it either in your computer or in paper. This will help you to not to lose any of your important.

14. Produce good diagrams of your own: Always try to include good charts or diagrams in your paper to improve quality. Using several and unnecessary diagrams will degrade the quality of your paper by creating "hotchpotch." So always, try to make and include those diagrams, which are made by your own to improve readability and understandability of your paper.

15. Use of direct quotes: When you do research relevant to literature, history or current affairs then use of quotes become essential but if study is relevant to science then use of quotes is not preferable.

16. Use proper verb tense: Use proper verb tenses in your paper. Use past tense, to present those events that happened. Use present tense to indicate events that are going on. Use future tense to indicate future happening events. Use of improper and wrong tenses will confuse the evaluator. Avoid the sentences that are incomplete.

17. Never use online paper: If you are getting any paper on Internet, then never use it as your research paper because it might be possible that evaluator has already seen it or maybe it is outdated version.

18. **Pick a good study spot:** To do your research studies always try to pick a spot, which is quiet. Every spot is not for studies. Spot that suits you choose it and proceed further.

19. Know what you know: Always try to know, what you know by making objectives. Else, you will be confused and cannot achieve your target.

20. Use good quality grammar: Always use a good quality grammar and use words that will throw positive impact on evaluator. Use of good quality grammar does not mean to use tough words, that for each word the evaluator has to go through dictionary. Do not start sentence with a conjunction. Do not fragment sentences. Eliminate one-word sentences. Ignore passive voice. Do not ever use a big word when a diminutive one would suffice. Verbs have to be in agreement with their subjects. Prepositions are not expressions to finish sentences with. It is incorrect to ever divide an infinitive. Avoid clichés like the disease. Also, always shun irritating alliteration. Use language that is simple and straight forward. put together a neat summary.

21. Arrangement of information: Each section of the main body should start with an opening sentence and there should be a changeover at the end of the section. Give only valid and powerful arguments to your topic. You may also maintain your arguments with records.

22. Never start in last minute: Always start at right time and give enough time to research work. Leaving everything to the last minute will degrade your paper and spoil your work.

23. Multitasking in research is not good: Doing several things at the same time proves bad habit in case of research activity. Research is an area, where everything has a particular time slot. Divide your research work in parts and do particular part in particular time slot.

24. Never copy others' work: Never copy others' work and give it your name because if evaluator has seen it anywhere you will be in trouble.

25. Take proper rest and food: No matter how many hours you spend for your research activity, if you are not taking care of your health then all your efforts will be in vain. For a quality research, study is must, and this can be done by taking proper rest and food.

26. Go for seminars: Attend seminars if the topic is relevant to your research area. Utilize all your resources.

27. Refresh your mind after intervals: Try to give rest to your mind by listening to soft music or by sleeping in intervals. This will also improve your memory.

28. Make colleagues: Always try to make colleagues. No matter how sharper or intelligent you are, if you make colleagues you can have several ideas, which will be helpful for your research.

29. **Think technically:** Always think technically. If anything happens, then search its reasons, its benefits, and demerits.

30. Think and then print: When you will go to print your paper, notice that tables are not be split, headings are not detached from their descriptions, and page sequence is maintained.

31. Adding unnecessary information: Do not add unnecessary information, like, I have used MS Excel to draw graph. Do not add irrelevant and inappropriate material. These all will create superfluous. Foreign terminology and phrases are not apropos. One should NEVER take a broad view. Analogy in script is like feathers on a snake. Not at all use a large word when a very small one would be sufficient. Use words properly, regardless of how others use them. Remove quotations. Puns are for kids, not grunt readers. Amplification is a billion times of inferior quality than sarcasm.

32. Never oversimplify everything: To add material in your research paper, never go for oversimplification. This will definitely irritate the evaluator. Be more or less specific. Also too, by no means, ever use rhythmic redundancies. Contractions aren't essential and shouldn't be there used. Comparisons are as terrible as clichés. Give up ampersands and abbreviations, and so on. Remove commas, that are, not necessary. Parenthetical words however should be together with this in commas. Understatement is all the time the complete best way to put onward earth-shaking thoughts. Give a detailed literary review.

33. Report concluded results: Use concluded results. From raw data, filter the results and then conclude your studies based on measurements and observations taken. Significant figures and appropriate number of decimal places should be used. Parenthetical remarks are prohibitive. Proofread carefully at final stage. In the end give outline to your arguments. Spot out perspectives of further study of this subject. Justify your conclusion by at the bottom of them with sufficient justifications and examples.

34. After conclusion: Once you have concluded your research, the next most important step is to present your findings. Presentation is extremely important as it is the definite medium though which your research is going to be in print to the rest of the crowd. Care should be taken to categorize your thoughts well and present them in a logical and neat manner. A good quality research paper format is essential because it serves to highlight your research paper and bring to light all necessary aspects in your research.

Informal Guidelines of Research Paper Writing

Key points to remember:

- Submit all work in its final form.
- Write your paper in the form, which is presented in the guidelines using the template.
- Please note the criterion for grading the final paper by peer-reviewers.

Final Points:

A purpose of organizing a research paper is to let people to interpret your effort selectively. The journal requires the following sections, submitted in the order listed, each section to start on a new page.

The introduction will be compiled from reference matter and will reflect the design processes or outline of basis that direct you to make study. As you will carry out the process of study, the method and process section will be constructed as like that. The result segment will show related statistics in nearly sequential order and will direct the reviewers next to the similar intellectual paths throughout the data that you took to carry out your study. The discussion section will provide understanding of the data and projections as to the implication of the results. The use of good quality references all through the paper will give the effort trustworthiness by representing an alertness of prior workings.

Writing a research paper is not an easy job no matter how trouble-free the actual research or concept. Practice, excellent preparation, and controlled record keeping are the only means to make straightforward the progression.

General style:

Specific editorial column necessities for compliance of a manuscript will always take over from directions in these general guidelines.

To make a paper clear

· Adhere to recommended page limits

Mistakes to evade

- Insertion a title at the foot of a page with the subsequent text on the next page
- Separating a table/chart or figure - impound each figure/table to a single page
- Submitting a manuscript with pages out of sequence

In every sections of your document

· Use standard writing style including articles ("a", "the," etc.)

· Keep on paying attention on the research topic of the paper

· Use paragraphs to split each significant point (excluding for the abstract)

· Align the primary line of each section

· Present your points in sound order

· Use present tense to report well accepted

· Use past tense to describe specific results

· Shun familiar wording, don't address the reviewer directly, and don't use slang, slang language, or superlatives

· Shun use of extra pictures - include only those figures essential to presenting results

Title Page:

Choose a revealing title. It should be short. It should not have non-standard acronyms or abbreviations. It should not exceed two printed lines. It should include the name(s) and address (es) of all authors.

Abstract:

The summary should be two hundred words or less. It should briefly and clearly explain the key findings reported in the manuscript--must have precise statistics. It should not have abnormal acronyms or abbreviations. It should be logical in itself. Shun citing references at this point.

An abstract is a brief distinct paragraph summary of finished work or work in development. In a minute or less a reviewer can be taught the foundation behind the study, common approach to the problem, relevant results, and significant conclusions or new questions.

Write your summary when your paper is completed because how can you write the summary of anything which is not yet written? Wealth of terminology is very essential in abstract. Yet, use comprehensive sentences and do not let go readability for briefness. You can maintain it succinct by phrasing sentences so that they provide more than lone rationale. The author can at this moment go straight to shortening the outcome. Sum up the study, with the subsequent elements in any summary. Try to maintain the initial two items to no more than one ruling each.

- Reason of the study - theory, overall issue, purpose
- Fundamental goal
- To the point depiction of the research
- Consequences, including definite statistics - if the consequences are quantitative in nature, account quantitative data; results of any numerical analysis should be reported
- Significant conclusions or questions that track from the research(es)

Approach:

- Single section, and succinct
- As a outline of job done, it is always written in past tense
- A conceptual should situate on its own, and not submit to any other part of the paper such as a form or table
- Center on shortening results - bound background information to a verdict or two, if completely necessary
- What you account in an conceptual must be regular with what you reported in the manuscript
- Exact spelling, clearness of sentences and phrases, and appropriate reporting of quantities (proper units, important statistics) are just as significant in an abstract as they are anywhere else

Introduction:

The **Introduction** should "introduce" the manuscript. The reviewer should be presented with sufficient background information to be capable to comprehend and calculate the purpose of your study without having to submit to other works. The basis for the study should be offered. Give most important references but shun difficult to make a comprehensive appraisal of the topic. In the introduction, describe the problem visibly. If the problem is not acknowledged in a logical, reasonable way, the reviewer will have no attention in your result. Speak in common terms about techniques used to explain the problem, if needed, but do not present any particulars about the protocols here. Following approach can create a valuable beginning:

- Explain the value (significance) of the study
- Shield the model - why did you employ this particular system or method? What is its compensation? You strength remark on its appropriateness from a abstract point of vision as well as point out sensible reasons for using it.
- Present a justification. Status your particular theory (es) or aim(s), and describe the logic that led you to choose them.
- Very for a short time explain the tentative propose and how it skilled the declared objectives.

Approach:

- Use past tense except for when referring to recognized facts. After all, the manuscript will be submitted after the entire job is done.
- Sort out your thoughts; manufacture one key point with every section. If you make the four points listed above, you will need a least of four paragraphs.

- Present surroundings information only as desirable in order hold up a situation. The reviewer does not desire to read the whole thing you know about a topic.
- Shape the theory/purpose specifically - do not take a broad view.
- As always, give awareness to spelling, simplicity and correctness of sentences and phrases.

Procedures (Methods and Materials):

This part is supposed to be the easiest to carve if you have good skills. A sound written Procedures segment allows a capable scientist to replacement your results. Present precise information about your supplies. The suppliers and clarity of reagents can be helpful bits of information. Present methods in sequential order but linked methodologies can be grouped as a segment. Be concise when relating the protocols. Attempt for the least amount of information that would permit another capable scientist to spare your outcome but be cautious that vital information is integrated. The use of subheadings is suggested and ought to be synchronized with the results section. When a technique is used that has been well described in another object, mention the specific item describing a way but draw the basic principle while stating the situation. The purpose is to text all particular resources and broad procedures, so that another person may use some or all of the methods in one more study or referee the scientific value of your work. It is not to be a step by step report of the whole thing you did, nor is a methods section a set of orders.

Materials:

- Explain materials individually only if the study is so complex that it saves liberty this way.
- Embrace particular materials, and any tools or provisions that are not frequently found in laboratories.
- Do not take in frequently found.
- If use of a definite type of tools.
- Materials may be reported in a part section or else they may be recognized along with your measures.

Methods:

- Report the method (not particulars of each process that engaged the same methodology)
- Describe the method entirely
- To be succinct, present methods under headings dedicated to specific dealings or groups of measures
- Simplify - details how procedures were completed not how they were exclusively performed on a particular day.
- If well known procedures were used, account the procedure by name, possibly with reference, and that's all.

Approach:

- It is embarrassed or not possible to use vigorous voice when documenting methods with no using first person, which would focus the reviewer's interest on the researcher rather than the job. As a result when script up the methods most authors use third person passive voice.
- Use standard style in this and in every other part of the paper - avoid familiar lists, and use full sentences.

What to keep away from

- Resources and methods are not a set of information.
- Skip all descriptive information and surroundings - save it for the argument.
- Leave out information that is immaterial to a third party.

Results:

The principle of a results segment is to present and demonstrate your conclusion. Create this part a entirely objective details of the outcome, and save all understanding for the discussion.

The page length of this segment is set by the sum and types of data to be reported. Carry on to be to the point, by means of statistics and tables, if suitable, to present consequences most efficiently.You must obviously differentiate material that would usually be incorporated in a study editorial from any unprocessed data or additional appendix matter that would not be available. In fact, such matter should not be submitted at all except requested by the instructor.

Content

- Sum up your conclusion in text and demonstrate them, if suitable, with figures and tables.
- In manuscript, explain each of your consequences, point the reader to remarks that are most appropriate.
- Present a background, such as by describing the question that was addressed by creation an exacting study.
- Explain results of control experiments and comprise remarks that are not accessible in a prescribed figure or table, if appropriate.
- Examine your data, then prepare the analyzed (transformed) data in the form of a figure (graph), table, or in manuscript form.

What to stay away from

- Do not discuss or infer your outcome, report surroundings information, or try to explain anything.
- Not at all, take in raw data or intermediate calculations in a research manuscript.
- Do not present the similar data more than once.
- Manuscript should complement any figures or tables, not duplicate the identical information.
- Never confuse figures with tables - there is a difference.

Approach

- As forever, use past tense when you submit to your results, and put the whole thing in a reasonable order.
- Put figures and tables, appropriately numbered, in order at the end of the report
- If you desire, you may place your figures and tables properly within the text of your results part.

Figures and tables

- If you put figures and tables at the end of the details, make certain that they are visibly distinguished from any attach appendix materials, such as raw facts
- Despite of position, each figure must be numbered one after the other and complete with subtitle
- In spite of position, each table must be titled, numbered one after the other and complete with heading
- All figure and table must be adequately complete that it could situate on its own, divide from text

Discussion:

The Discussion is expected the trickiest segment to write and describe. A lot of papers submitted for journal are discarded based on problems with the Discussion. There is no head of state for how long a argument should be. Position your understanding of the outcome visibly to lead the reviewer through your conclusions, and then finish the paper with a summing up of the implication of the study. The purpose here is to offer an understanding of your results and hold up for all of your conclusions, using facts from your research and generally accepted information, if suitable. The implication of result should be visibly described. Infer your data in the conversation in suitable depth. This means that when you clarify an observable fact you must explain mechanisms that may account for the observation. If your results vary from your prospect, make clear why that may have happened. If your results agree, then explain the theory that the proof supported. It is never suitable to just state that the data approved with prospect, and let it drop at that.

- Make a decision if each premise is supported, discarded, or if you cannot make a conclusion with assurance. Do not just dismiss a study or part of a study as "uncertain."
- Research papers are not acknowledged if the work is imperfect. Draw what conclusions you can based upon the results that you have, and take care of the study as a finished work
- You may propose future guidelines, such as how the experiment might be personalized to accomplish a new idea.
- Give details all of your remarks as much as possible, focus on mechanisms.
- Make a decision if the tentative design sufficiently addressed the theory, and whether or not it was correctly restricted.
- Try to present substitute explanations if sensible alternatives be present.
- One research will not counter an overall question, so maintain the large picture in mind, where do you go next? The best studies unlock new avenues of study. What questions remain?
- Recommendations for detailed papers will offer supplementary suggestions.

Approach:

- When you refer to information, differentiate data generated by your own studies from available information
- Submit to work done by specific persons (including you) in past tense.
- Submit to generally acknowledged facts and main beliefs in present tense.

Administration Rules Listed Before Submitting Your Research Paper to Global Journals Inc. (US)

Please carefully note down following rules and regulation before submitting your Research Paper to Global Journals Inc. (US):

Segment Draft and Final Research Paper: You have to strictly follow the template of research paper. If it is not done your paper may get rejected.

- The **major constraint** is that you must independently make all content, tables, graphs, and facts that are offered in the paper. You must write each part of the paper wholly on your own. The Peer-reviewers need to identify your own perceptive of the concepts in your own terms. NEVER extract straight from any foundation, and never rephrase someone else's analysis.

- Do not give permission to anyone else to "PROOFREAD" your manuscript.

- Methods to avoid Plagiarism is applied by us on every paper, if found guilty, you will be blacklisted by all of our collaborated research groups, your institution will be informed for this and strict legal actions will be taken immediately.)
- To guard yourself and others from possible illegal use please do not permit anyone right to use to your paper and files.

Criterion for Grading a Research Paper (Compilation) by Global Journals Inc. (US)

Please note that following table is only a Grading of "Paper Compilation" and not on "Performed/Stated Research" whose grading solely depends on Individual Assigned Peer Reviewer and Editorial Board Member. These can be available only on request and after decision of Paper. This report will be the property of Global Journals Inc. (US).

Topics	Grades		
	A-B	**C-D**	**E-F**
Abstract	Clear and concise with appropriate content, Correct format. 200 words or below	Unclear summary and no specific data, Incorrect form Above 200 words	No specific data with ambiguous information Above 250 words
Introduction	Containing all background details with clear goal and appropriate details, flow specification, no grammar and spelling mistake, well organized sentence and paragraph, reference cited	Unclear and confusing data, appropriate format, grammar and spelling errors with unorganized matter	Out of place depth and content, hazy format
Methods and Procedures	Clear and to the point with well arranged paragraph, precision and accuracy of facts and figures, well organized subheads	Difficult to comprehend with embarrassed text, too much explanation but completed	Incorrect and unorganized structure with hazy meaning
Result	Well organized, Clear and specific, Correct units with precision, correct data, well structuring of paragraph, no grammar and spelling mistake	Complete and embarrassed text, difficult to comprehend	Irregular format with wrong facts and figures
Discussion	Well organized, meaningful specification, sound conclusion, logical and concise explanation, highly structured paragraph reference cited	Wordy, unclear conclusion, spurious	Conclusion is not cited, unorganized, difficult to comprehend
References	Complete and correct format, well organized	Beside the point, Incomplete	Wrong format and structuring

INDEX

Global Journal of Researches in Engineering

Visit us on the Web at www.GlobalJournals.org | www.EngineeringResearch.org
or email us at helpdesk@globaljournals.org

ISSN 9755861