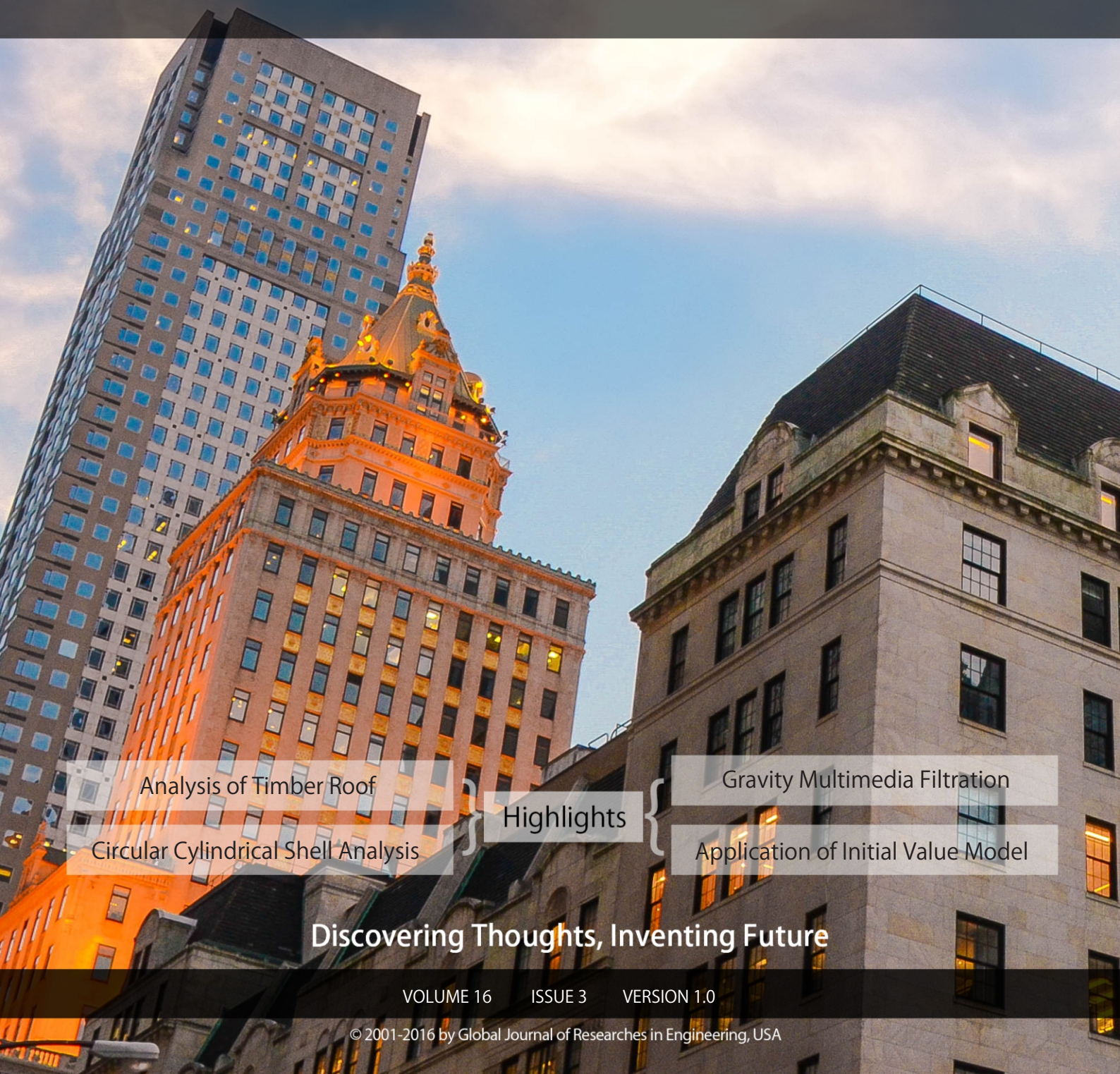
Online ISSN : 2249-4596
Print ISSN : 0975-5861
DOI : 10.17406/GJRE

Global Journal

of Researches in Engineering: E

Civil and Structural Engineering



Analysis of Timber Roof

Circular Cylindrical Shell Analysis

Highlights

Gravity Multimedia Filtration

Application of Initial Value Model

Discovering Thoughts, Inventing Future

VOLUME 16 ISSUE 3 VERSION 1.0

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Open Association of Research Society

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Contents of the Issue

Global Journal of Researches in Engineering: E
Civil And Structural Engineering
Volume 16 Issue 3 Version 1.0 Year 2016
Type: Double Blind Peer Reviewed International Research Journal
Publisher: Global Journals Inc. (USA)
Online ISSN: 2249-4596 & Print ISSN: 0975-5861

Using Crashed Bricks as Top Layer in Gravity Multimedia Filtration

By Dr. Faez Alkathili & Dr. Monther Alalousi

Abstract- This research aims to eliminate the top sedimentation CAKE in gravity filtration for water purification in almost all water treatment plants due of blocking of large turbidity particles on top of first filter layer, it is strongly recommended to use a coarse materials that is lighter in density from sand, and can be float above the sand layer during the filtration circle back washing, our goal idea is to used crashed bricks due to its huge availability, cheep, high porosity &, less specific weight, bricks well washed and crashed mechanically then sieved to perform the required size, lab tests was made using waters supplied from city main network mixed with controlled percentage of kaolin as turbidity. Chemical are used to coagulate suspended materials before the filtration stage, chemical used include alum with some catalyst, such as poly electrolytes.

Keywords: *drinking water purification, filtration, water, crashed brick, sand, kaolin, turbidity.*

GJRE-E Classification : *FOR Code: 090599*

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Dr. Faez Alkathili [α] & Dr. Monther Alalousi [σ]

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An integrated 5,50 m high filtration unit was constructed in the laboratory, it included four main units: an axial flocculating unit, a filtration unit , injection unit for pumping coagulants and clay materials, and a backwashing unit, a piezometric board is also included to give reading at each 10cm of filter height . Water is supplied to the system through a constant head tank by gravity action. filtration is done through two mediums ,a crushed brick layer2 to 5mm sizes(30to40)cm deep and a quartz sand layer 0-.60to 0.75mm (30to40)cm deep.

The lab experimental test, using drinkable water supply, with addition of kaolin (fine mud used as turbidity) to increase turbidity & find the best combination of variables, loading, to highest water yield together with highest efficiency, experiments were run to find the effect of filtration rate, type & depth of filtration materials, effect of coagulating material & catalyst in addition to flocculation time and velocity gradient.

Results of above showed that:-

1. Suggested crashed brick should be washed perfectly to clean away any salts that might be within the brick materials, then sieved to have homogenous particles.
2. All tests indicate the possibility of using crashed bricks as top layer in gravity multimedia filtration with very positive results,
3. Increasing efficiency through proper control of mixing, turbidity, filtration rate and velocity gradient.
4. Experimental filtration gives V.good Results for filter working cycle" filtration cycle increased to at least twice ", double quantities of water production & best quality.
5. Labs tests shows a positive results on removing about 10%-15% TDS from influent water.
6. It is recommended to use polymer with alum for coagulation for better Results.
7. Filtration efficiency increased to up to 98% at laboratory Tests. When using the proposed crashed brick as first layer.
8. It is important to check Coagulant potential value for better Results.
9. Crashed bricks have to be replaced with new layer after approximate 60 cleaning cycle.
10. Tests also indicate that there will be presented an intermediate layer between cashed brick and the top sand layer " this layer will be a mixed of proposed crashed brick with top fine sand " the tests also indicate that this layer will be about 10 cm in thickness:.
11. All gravity filters have its own standard coefficient which is called filtration coefficient "lumda". during those experimental test we tried also to calculate the values of this coefficients" which ranged from 1 to 0.66 "
12. The new investigations are, when the filter depth is shorter than 0.4 m, no significant efficiency is observed. For filter depth ranging from 0.4 -0.8 m, a significant increase is observed in the filter efficiency.
13. The filtration Rate slowly affect the removal efficiency when filtration Rate < 4 $m^3/m^2/h$.
14. The removal efficiency reaches up to 80 %. When filtration rate is 4 $m^3/m^2/hr$ >filtration Rate < 12 $m^3/m^2/hr$.
15. With more increase in filtration Rate, the removal efficiency comes down to less than 40%.
16. Only crashed brick is used in this study, it is highly recommended to check the possibility of crashed stone, crashed concrete, and even palm tree leaf.

Keywords: drinking water purification, filtration, water, crashed brick, sand, kaolin, turbidity.

I. Purpose

The purposes: compliance with treatment technique regulatory requirements; targeting impurities; and producing a longer filtration cycle and better water purification. When source water is generally within the turbidity range of 1 to 5 NTU, it may be a candidate for water treatment gravity filtration.

II. Introduction

Water purification is the removal of contaminants from untreated water to produce drinking water that is pure enough for the most critical of its intended uses, usually for human consumption. Substances that are removed during the process of drinking water treatment include suspended solids, bacteria, algae, viruses, fungi, minerals such as iron, manganese and sulfur, and other chemical pollutants such as fertilizers.

Measures taken to ensure water quality not only relate to the treatment of the water, but to its

Author α: e-mail: faiz_alkathily@hotmail.com

conveyance and distribution after treatment as well. It is therefore common practice to have residual disinfectants in the treated water in order to kill any bacteriological contamination during distribution.

World Health Organization (WHO) guidelines are generally followed throughout the world for drinking water quality requirements. In addition to the WHO guidelines, each country or territory or water supply body can have their own guidelines in order for consumers to have access to safe drinking water.

Algae are common and normal inhabitants of surface waters and are encountered in every water supply that is exposed to sunlight. Algae typically range in size from 5 to 100 microns.

Many microorganisms commonly found in source waters do not pose health risk to humans, As Filters represent the key unit process for particles removal in all surface water treatment. Optimization used prior to the filtration process will control loading rates while allowing the system to achieve maximum filtration rates. Using crashed brick as first layer in addition to the other filter media such as fine quartzite sand and gravel, may be considered as one of several treatment processes that can be applied in combination with others to produce potable water. Low turbidity (<20 NTU) and algae count in the order of 106 units/liter among other factors,

III. History of the Gravity Water Filter

1835… London, England. Queen Victoria recognized the increasing health dangers of the drinking water supply. Cholera and typhoid epidemics were commonplace.

She requested John Doulton (of later to become Royal Doulton), to produce a water filter with his ceramic making capabilities. Using various earth and clay materials, he created the first gravity water filter stoneware, Doulton water filters. With her satisfaction in the filter, Queen Victoria bestowed upon Doulton the right to apply the Royal Crest to each of his units.

1862…John Doulton's son, Henry Doulton introduced the Doulton Manganour (new, efficient purifying medium which could be readily renewed), carbon water filter. With Louis Pasteur's new findings about bacteria in this same period, a more advanced understanding of bacteria made it possible for the creation of a porous ceramic which could filter out tiny organisms. Gravity fed water filtration! And the Berkey…? We're getting there…

1901… King Edward VII knighted Henry Doulton and honored his company use to the word ROYAL in reference to its products. Hence the name "Royal Berkey", one of the larger gravity water filter units available today. Doulton's water filters gained popularity and wide spread use by hospitals, laboratories and residential water filtration throughout the world as far away as Africa and the Middle east.

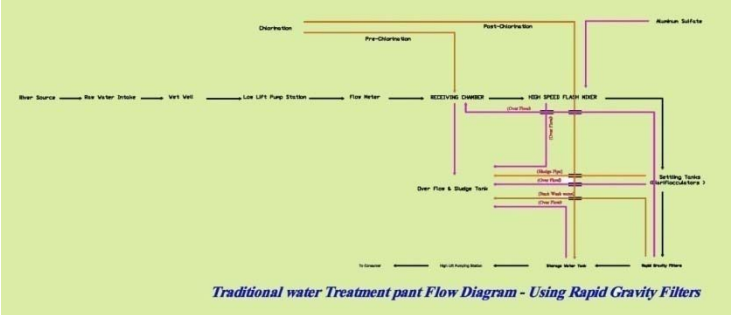
Throughout the decades, the Doulton company modified the ceramic filters by adding small, pure silver particles (anti-microbial), which made the filter elements self-sterilizing and they registered the trade name "British Berkefeld". Once these improvements were made, the gravity filters became popular with, and trusted by relief organizations such as UNICEF, the Peace Corps, Red Cross and used in over 140 countries throughout the world.

1998…Through a distribution partnership with British Berkefeld, the US based company, "New Millennium Concepts", began distributing their products locally. NML pushed the envelope of the product and created the "Black Berkey" purification element. Black Berkey purification elements are more powerful than any other gravity filter element currently available. They were tested with 10,000 times the amount of pathogens required for standard protocol and removed 100% of the pathogens (tested under an electron microscope), setting a new standard in water purification.

IV. Processes for Drinking Water Treatment

A combination selected from the following processes is used for municipal drinking water treatment worldwide:

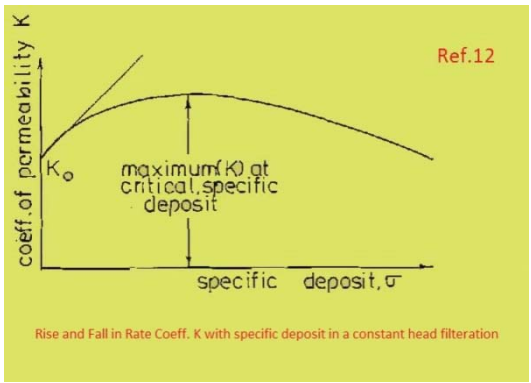
- Pre-chlorination - for algae control and arresting any biological growth
- Aeration - along with pre-chlorination for removal of dissolved iron and manganese
- Coagulation - for flocculation
- Coagulant aids, also known as polyelectrolyte - to improve coagulation and for thicker floc formation
- Sedimentation - for solids separation, that is, removal of suspended solids trapped in the floc
- *Filtration* - removing particles from water
- Desalination - Process of removing salt from the water
- Disinfection - for killing bacteria.



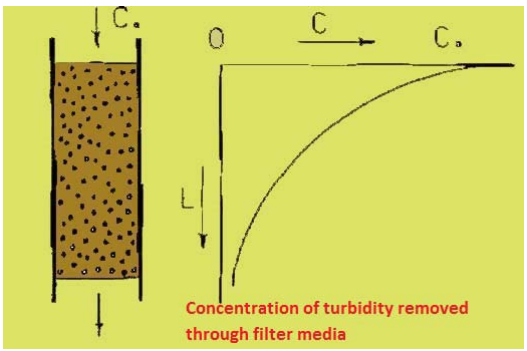
Technologies for potable water treatment are well developed, and generalized designs are available that are used by many water utilities (public or private). In addition, a number of private companies provide patented technological solutions. Automation of water and waste-water treatment is common in the developed world. Capital costs, operating costs available quality monitoring technologies, locally available skills typically dictate the level of automation adopted

V. Effect of Filter Depth on the Removal Efficiency

It is well known that, the filter depth has a direct relation with the filter efficiency, i.e., increasing the filter depth will increase the filter efficiency. Effect of filter depth on the removal efficiency.



The new investigations are, when the filter depth is shorter than 0.4 m, no significant efficiency is observed. For filter depth ranging from 0.4 -0.8 m, a significant increase is observed in the filter efficiency.

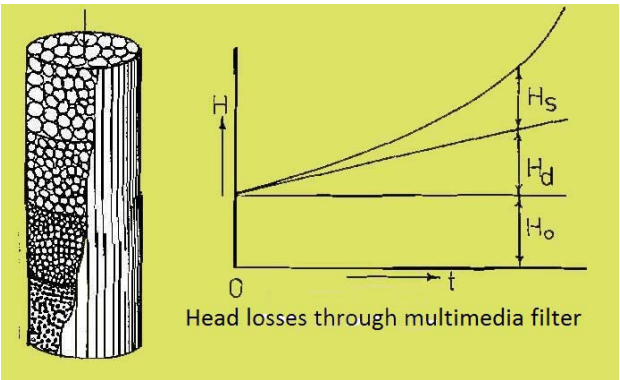


VI. Effect of Filtration Rate on the Removal Efficiency

1st - The filtration Rate slowly affect the removal efficiency when filtration Rate < 4 $m^3/m^2/h$.

2nd – The removal efficiency reaches up to 80 %. When filtration rate is 4 $m^3/m^2/hr$ >filtration Rate < 12 $m^3/m^2/hr$,

3rd - With more increase in filtration Rate, the removal efficiency comes down to less than 40%.

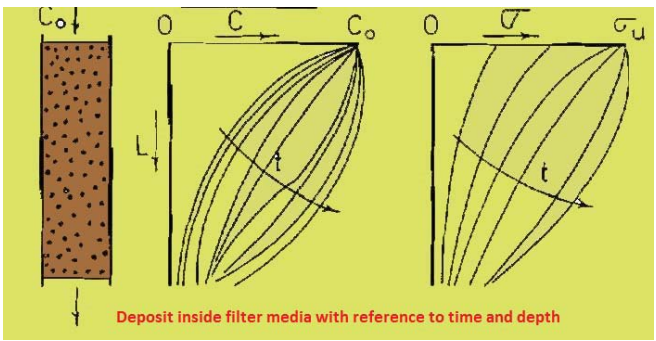


VII. Effect of Media Particle Size on Removal Efficiency

The Media particle size strongly affects the filter efficiency.

1st - High effect of grain size on the performance of direct filtration. Removal efficiency comes down to insignificant value at using particle of size >5mm.

2ND - Particle size of 0.1-2 mm is recommended. At some cases of pre-treatment work, particle size greater than 3 mm may be of use.

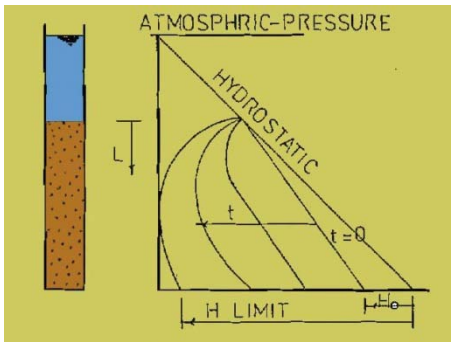


VIII. Effect of Alum Dose Concentration on the Removal Efficiency

Several factors may Govern the optimum dose of alum such as, size of Turbidity particles, turbidity level, and the G potential of Coagulation, surface loading, etc. many studies shows the effect of coagulant dosage on the performance of direct filtration, some stated that, there exist an optimum dose at which the filter produces high effluent efficiency.

IX. Filtration Mechanism

Filtration depends mainly on kind of particles, and the filter media. In addition to Rate of filtration, Dosage and type of coagulants Used In general One or more of below factors affect the filtration:-

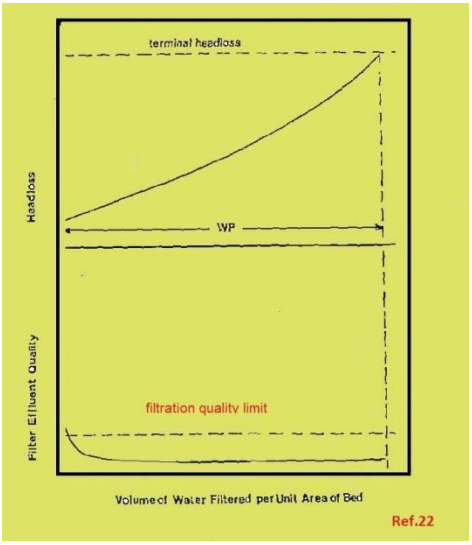


1st - deposit mechanism, as the particles bigger than the size of media porosity will be settled over the media, also the suspended solid take a specifies path depend mainly on porosity but even though some of the particles pass through the media, as there are some factors affecting the mechanism such as direct distortion, Brownian movement or van der wave forces,

2nd – fixation mechanism, which is the sedimentation of particles over the filter Surface as part of slow filtration flow, or vibration of particles because of different electrical charges ,or van der waals forces.

3rd – detachment mechanism, as part of above forces and particles being catch either over the surface /or in side media porosity, the filtration rate may increase, and the flow may change from laminar flow to Turbulent, so particles may separated again and move deep or even pass through the filter media, this can be solved using stronger polymers, and variable filtration flow,

To solve above we can do either



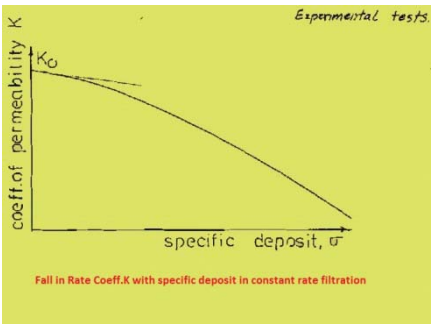
1st – increase particles size inside the media be injecting polymers inside the filter.

2nd – reduce particle size inside the passing solution by pumping water from down to up.

3rd – Reduce filtration rate. Inside each layer. Which can be done using radial filtration?

X. Theoretical Analysis of Filtration

As deep filter media used to inshore removal of collides, then continues increase in head losses till the filter reach its blocked stage. And then Back wash should be done.

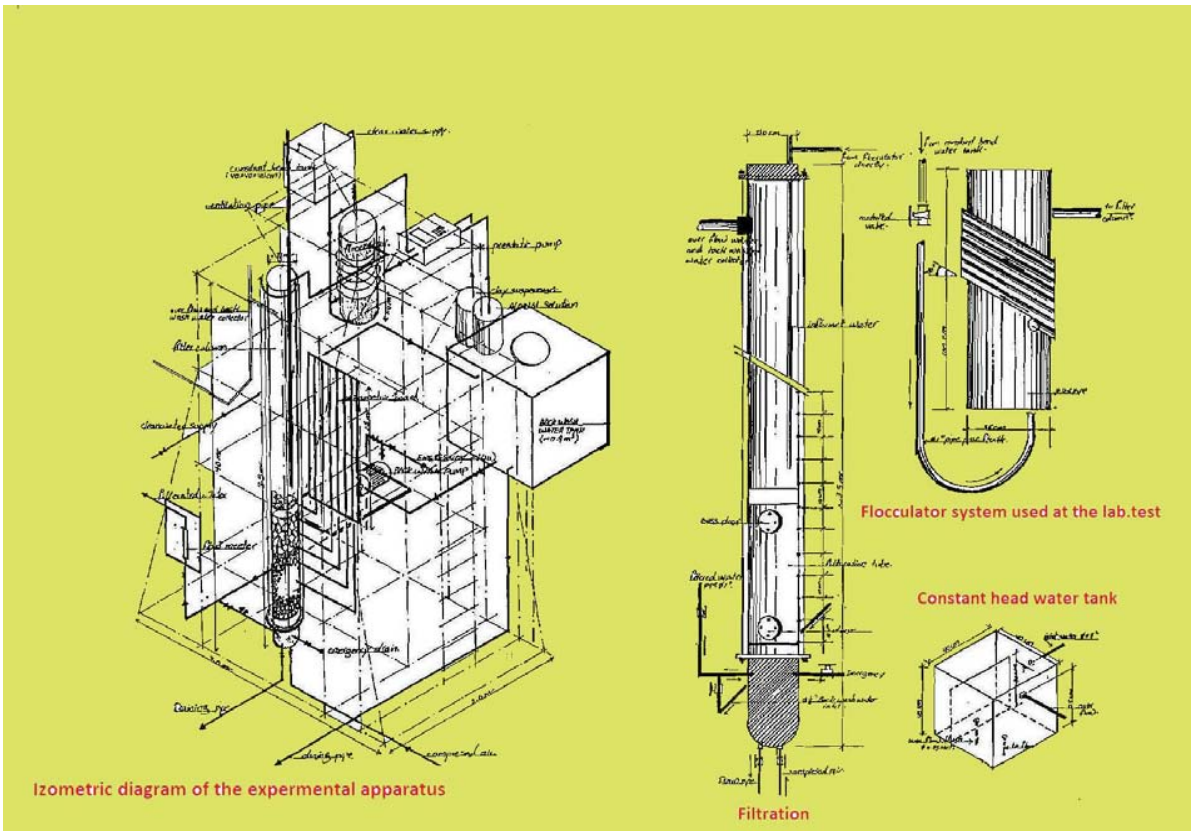


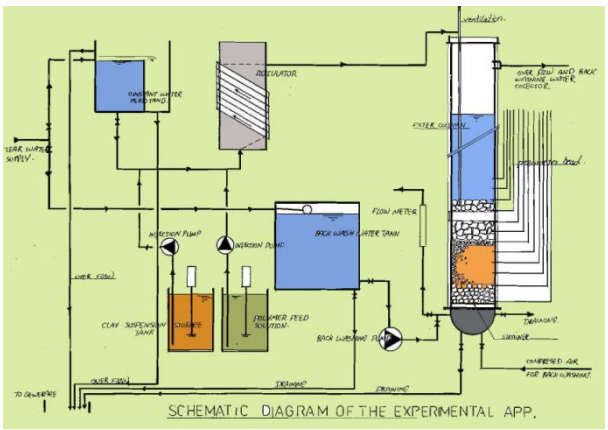
XI. Laboratory Tests Performed

An integrated 5,50 m high Direct filtration unit was constructed in the laboratory, it included four main units: an axial flocculating unit, a filtration unit , injection unit for pumping coagulants and clay materials, and a backwashing unit, a piezometric board is also included tot give reading at each 10cm of filter height . Water is supplied to the system through a constant head tank by gravity action. filtration is done through two mediums ,a coarse media layer with 2 to 5mm sizes (30to40)cm deep, and a quartz sand layer 0-.60to 0.75mm (30to40)cm deep.

The first stage included the laboratory procedure, using the constructed filtration system, Baghdad water supply was used, with the addition of

kaolin (fine mud used as turbidity)to increase turbidity to find the best combination of variables, loading, to highest water yield together with highest efficiency, experiments were run to find the effect of filtration rate, type &and depth of filtration materials, effect of coagulating material and added catalyst in addition to the control of flocculation time and velocity gradient.





a) Filtration Unit

As this study is very important, and to get best results, a complete filtration unit is constructed at the lab. Filter depth is according to real gravity filters with surface area of 0.0246m2, and filtration rate up to 750 l/h . a serious of tests was made with different filtration media and depth to achieve the best results.

Alla experimental test are perfumed using constant rate filtration as the water level will stay constant throughout test time, which in another words the filtration rate will be variable all the time depending on the deposit of turbidity within filter media voids,

b) Additional apartments used with the lab. Tests

Turbidity reader in FTU "DRALANGE-LTD,5"

Magnetic mixer "Magnetic stirrer KAMAG RET, TYPE RET, 620 W"

Turbidity injection pump "STA-PERLSTIC PUMP, LABSCO."

Mixer type LASCO Germany

PH Reader "LAVIBONDA, 2000"

Conductivity & Temperature reader "PHILIPS, PW 9525"

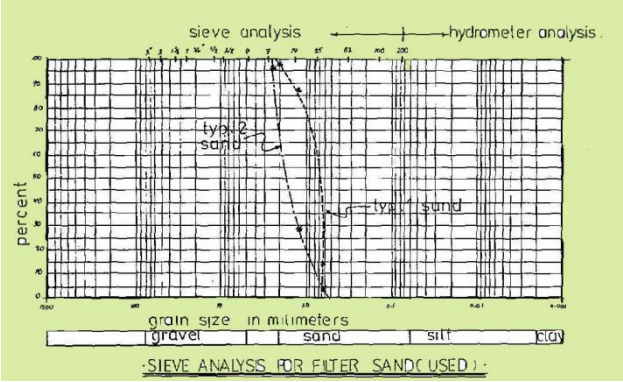
Digital balance "SARTORIUS, TYPE 1501"

Air compressor "KHOSLA, INDIA 2.2 KW, 400 R.P.M"

c) Materials used in the test

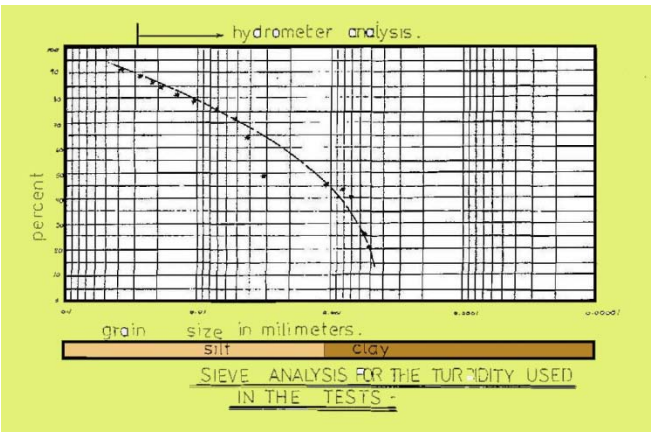
See table No.1

1. Corse sand type 1 & 2, effective diameter 0.75 millimeters and homogenous factor of 2,66.
2. Coarse crashed brick, effective diameter 4,50 millimeters and homogenous factor of 1,45.



SIEVE ANALYSIS FOR FILTER SAND(USED).

3. Fine crashed brick, effective diameter 2,90 millimeters and homogenous factor of 1,37.
4. Homogenous gravel, Coarse crashed brick, effective diameter 8 - 10 millimeters.



SIEVE ANALYSIS FOR THE TURBIDITY USED IN THE TESTS.

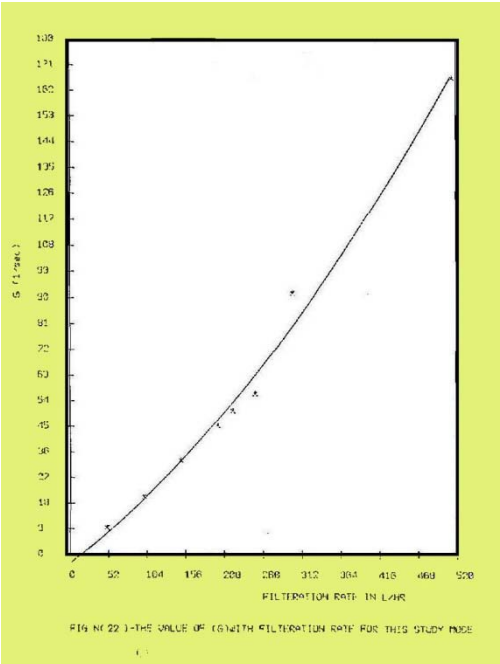


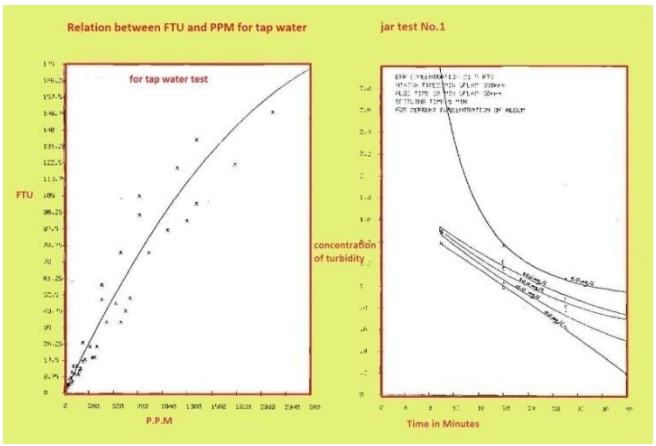
FIG N(22)-THE VALUE OF (G)WITH FILTERATION RATE FOR THIS STUDY MODE

d) Jar test

Jar test was done to define the best quantities of coagulant to be injected each time all water test done at the past years indicates that the maximum turbidity not exceed 320.0 milligram per letters (p.p.m) equal to FTU=21.5 (FORMAZIN TUBIDITY UNIT).

Alum was injected at the rates 5,10,15,20,25 milligram/litters, attached diagram shows the flocculation, and clearly indicates that 15 milligram / litters is the optimum.

Second group of test was performed fixing alum dose as 15.0 milligram / letters, and variable speed from 20 to 500 rpm for 20 minutes.



Also number of test was performed to find best velocity and best time of mixing. results as per attached fig.

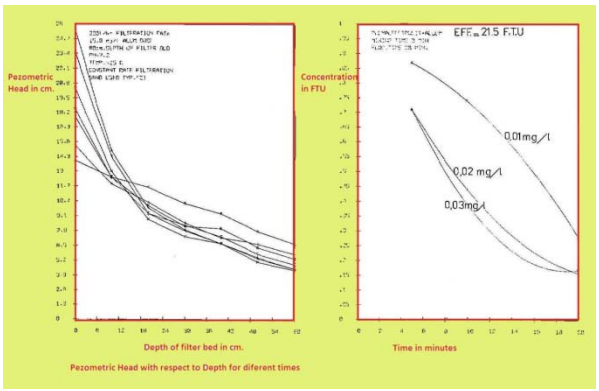
e) Depth of crashed brick to be used

To establish the best depth of crashed brick Type-1,physical property for the used media are shown in the table below :-

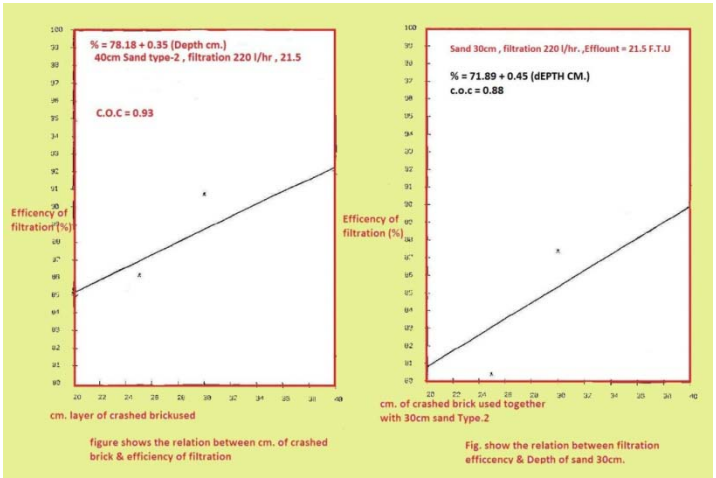
specification / material.	coff.of permeab. cm/sec	density gm/cm³	porosity %	specific weight	D_{10}	D_{16}	D_{50}	D_{60}	effective size (E)	coeff. of uniformity	geometric mean size (Mg)	geometric standard deviation (σg)
sand typ. 1	0,205	1,775	30,799	2,565	0,60	0,58	0,65	0,70	0,60	1,1666	0,65	1,1206
sand typ. 2	0,445	1,569	37,506	2,511	0,75	0,90	1,8	2,00	0,75	2,6666	1,90	2,00
cr.brick typ.1	8,78	1,072	5 5,72	2,421	4,50	4,80	7,00	8,00	4,50	1,777	7,00	1,4583
cr.brick typ.2	4,155	1,145	52,705	2,421	2,90	3,00	3,50	4,00	2,90	1,379	3,50	1,1666
sand(1-2(1:1))	0,553	1,531	40,56	2576								

TABLE NO(1).

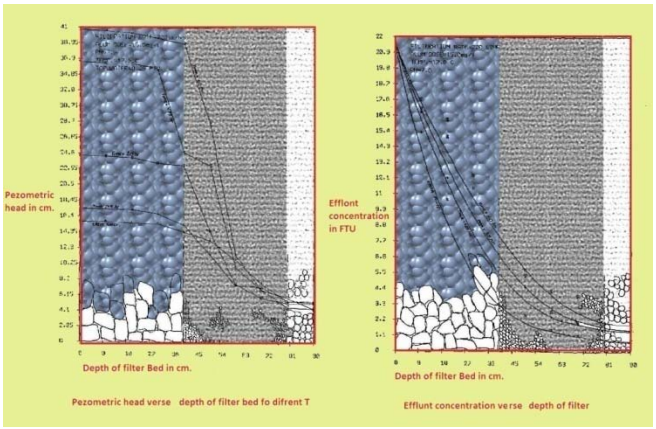
Number of experimental test was performed by fixing filtration rate at 220 l /hr. and influent turbidity "Co" equal to Av=21.5 F.T.U which equal 230 milligram / litter (p.p.m), alum dose 15.0 milligram / litter (p.p.m) and depth of sand media 30 ,40 cm , calculating effluent turbidity "C" from time to time to calculate the filter efficiency,



Figures bellow indicates the relation between filter efficiency with respect to different crashed brick depth together with 20 & 40cm sand media,



Results show clearly that the efficiency of filtration increased up to crashed brick layer of 40 cm, then the efficiency droped. According to this information the sand layer is fixed to be 40 cm and the crashed brick layer type-1 is fixed to be 40 cm during the following experimental tests



XII. Experimental Test at Lab

A number of experimental test perfumed at lab. Using drinking water from city main mixed with controlled kaolin as turbidity, tests divided in groups where all variables are fixed and only one character is changed to study the results. About 20 full lab. Tests are chosen from 68 tests for this study as final results.

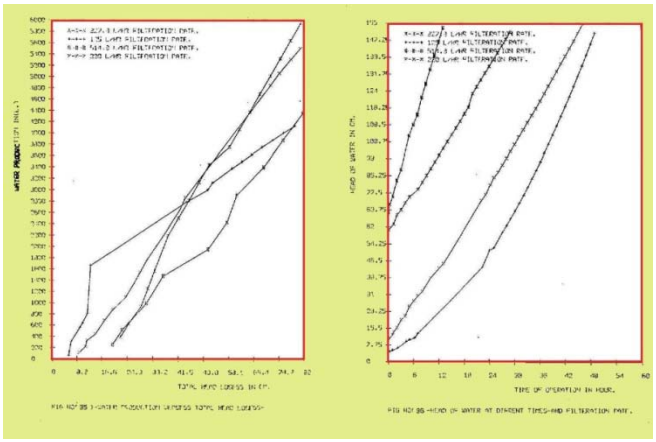
Coagulants used in the tests is Alum with dosing rates of 15.0 milligram / litter ,in groups 1,3,5 , and alum with Polly electrolytes dosing rage 0.1 to 0.01 milligram / letter in groups 2,4,6 .

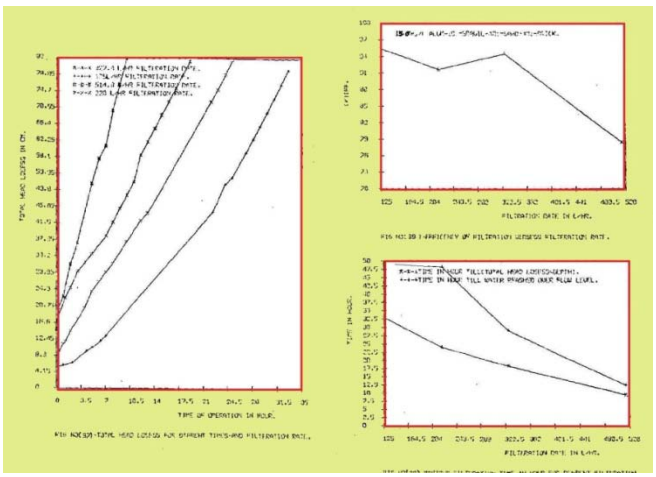
Filtration rates used in lab. Tests are 125,220,327.3,514.3 letter / hr. “equal to 2.6, 6.25 ,9. 43, 14.82 m3 /h respectively “

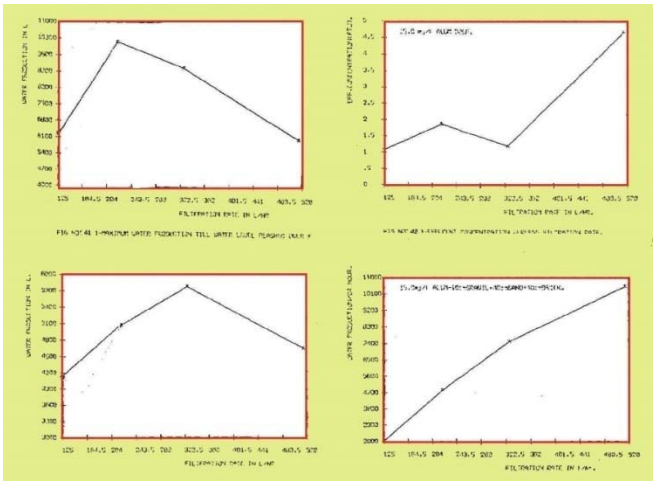
Filtration media multiple media filters are used, crashed brick and sands are as described previously.
Tests results are shown in bellow figures:-

First Group Test
Variable filtration Rate
Coagulant: Alum 15.0 mg/l
Sand: Type 2
Depth of Filtration Media: 40cm
Aggregate layer : 10 cm

SPECIFICATION.	TEST NO.1	TEST NO.2	TEST NO.3	TEST NO.4
FILTER TYP	DUAL MED.	DUAL MED.	DUAL MED.	DUAL MED.
SAND TYP.	NO.2	NO.2	NO.2	NO.2
SAND DEPTH IN CM.	40cm.	40cm.	40cm.	40cm.
CRASHED BRICK TYP.	NO.1	NO.1	NO.1	NO.1
BRICK DEPTH IN CM.	40cm.	40cm.	40cm.	40cm.
GRAVIL DEPTH IN CM.	10cm.	10cm.	10cm.	10cm.
FILTERATIN RATE.	327.3L/HR	125L/HR	514.3L/HR	220L/HR
INFLUNT TURBIDITY.	22 FTU	23 FTU	21.8FTU	22.7 FTU
EFFLOUNT TUBIDITY.	236.7MG/L 1.21FTU	249.5MG/L 1.0714FTU	234.1mg/l 4.685FTU 13.0mg/l	246.7mg/l 1.876 FTU
EFFICIENCY(%)	94.5%	95.34%	78.5%	91.76%
WATER TEMPRETURE.	15.6 C	16.6 C	16.1 C	16.6 C
PH	7.4 PH	7.4 PH	7.4 PH	7.4 PH
COAGULANT.TYP.	ALUM	ALUM	ALUM	ALUM
COAGULANT DOSE(mg/l)	15.0mg/l	15.0mg/l	15.0mg/l	15.0mg/l
VELOSITY GRADENT(G)	(90.524)	(25.579)	(166.63)	(52.873)
TIME FOR BACK WASH.	29 HR	49.1 HR	13.56 HR	48.2 HR
TIME FOR TOTAL HEAD LOSSES =80 cm.	18.4 HR	33 HR	9.6 HR	24.1 HR
TOTAL WATER PROD.	9077 L	4537.5 L	6063.1 L	10174.5L
TOTAL WATER PROD.TIL T.H.L=80 cm.	5760 L	2937.5 L	4642.5 L	5070.5 L
T.H.L VERSUS TIME SEE FIG NO.	(37)	(37)	(37)	(37)
WATER LEVEL VERSUS TIME(SEE FIG NO.)	(36)	(36)	(36)	(36)

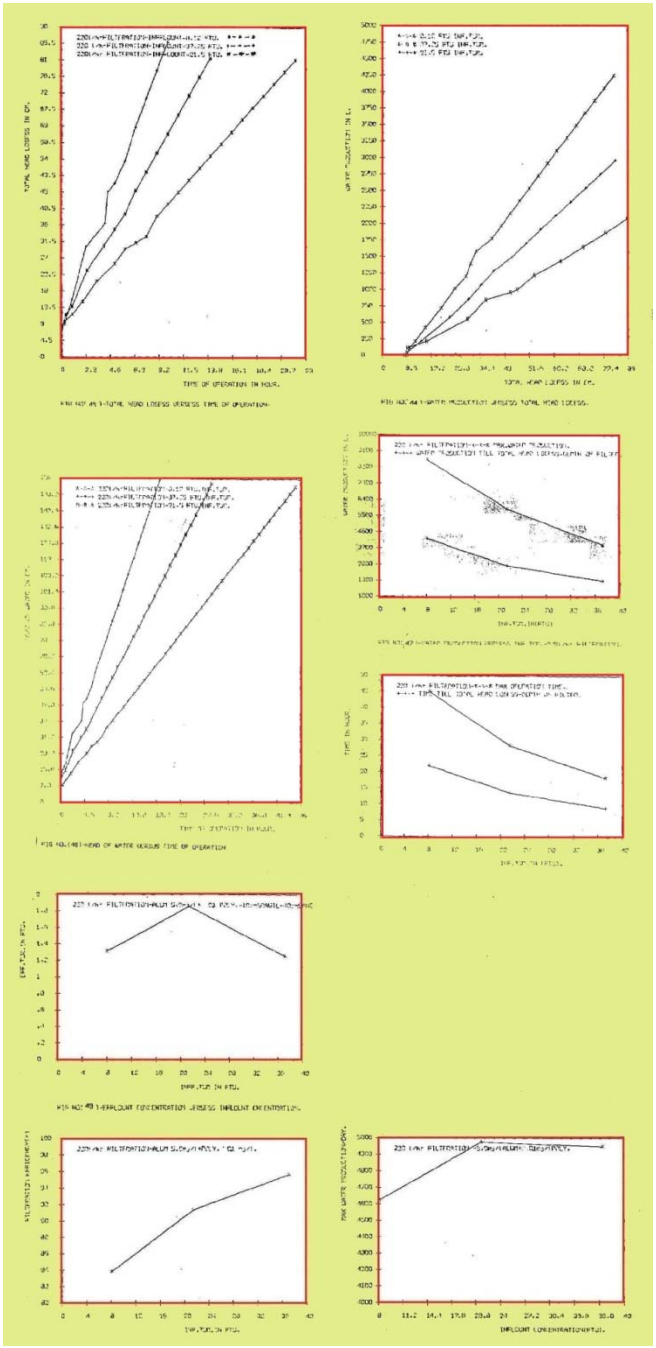






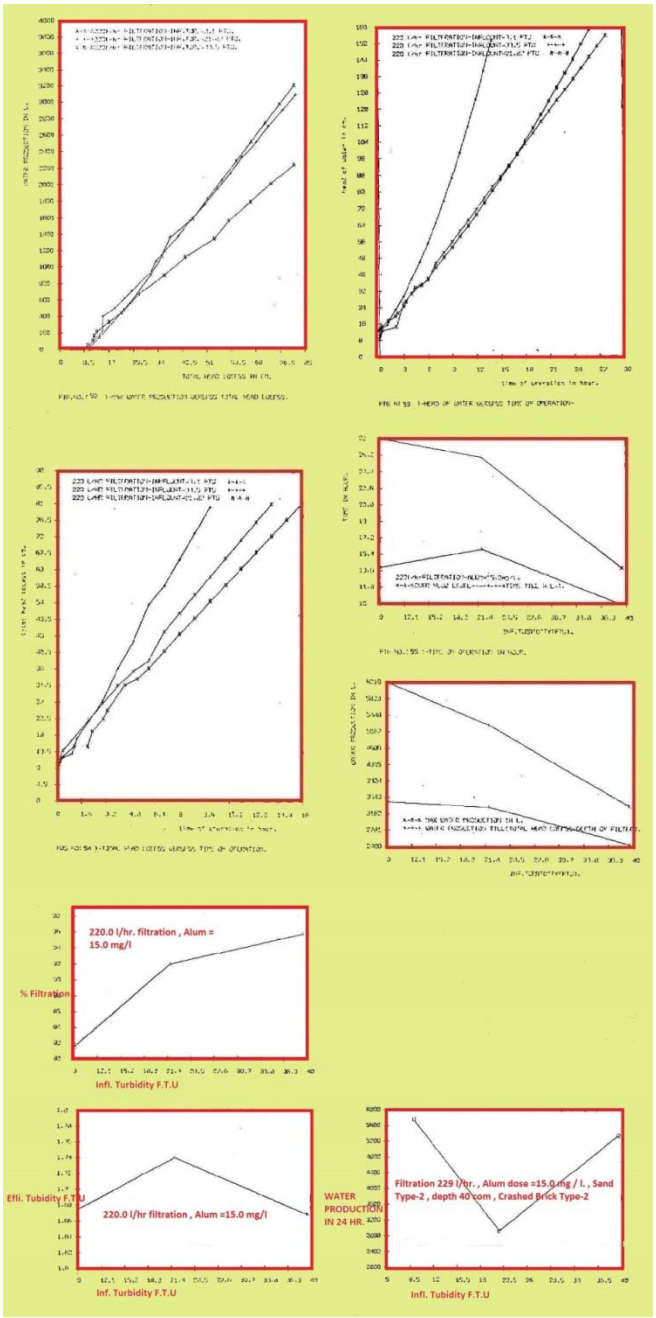
Fixed filtration Rate
Coagulant: Alum5.0mg/l
+Polyelectrolyte 0.1mg/l
Sand: Type 2
Depth of Filtration Media: 40cm
Aggregate layer : 10 cm

SPECIFICATION.	TEST NO.5	TEST NO.6	TEST NO.7
FILTER TYP	DUAL MED.	DUAL MED.	DUAL MED.
SAND TYP.	NO.2	NO.2	NO.2
SAND DEPTH IN CM.	40cm.	40cm.	40cm.
CRASHED BRICK TYP.	NO.1	NO.1	NO.1
BRICK DEPTH IN CM.	40cm.	40cm.	40cm.
GRAVIL DEPTH IN CM.	10cm.	10cm.	10cm.
FILTERATIN RATE.	220 L/HR	220 L/HR	220 L/HR
INFLUNT TURBIDITY.	8.12 FTU 57.5mg/l	37.25 FTU 432.5mg/l	21.5 FTU 231.5mg/l
EFFLOUNT TUBIDITY.	1.313FTU	1.257FTU	1.875FTU 13.0mg/l
EFFICIENCY(%)	83.83%	95.625%	91.363%
WATER TEMPRETURE.	11.6 C	14.8 C	14.3 C
PH	7.4 PH	7.4 PH	7.4 PH
COAGULANT.TYP.	ALUM+POLY	ALUM+POLY	ALUM+POLY
COAGULANT DOSE(mg/l)	5.0 ALUM+ 0.1 POLY.	5.0 ALUM+ 0.1 POLY.	5.0 ALUM+ 0.1 POLY.
VELOSITY GRADENT(G)	(50.816)	(49.5408)	(49.728S)
TIME FOR BACK WASH.	45 HR	18.4 HR	28.4 HR
TIME FOR TOTAL HEAD LOSSES =80 cm.	22 HR	9.1 HR	13.7 HR
TOTAL WATER PROD.	8612.5L	3928.8L	5899.4L
TOTAL WATER PROD.TIL T.H.L=80 cm.	4242.5L	1929.3L	2749.4L
T.H.L VERSUS TIME SEE FIG NO.	(45)	(45)	(45)
WATER LEVEL VERSUS TIME(SEE FIG NO.)	(46)	(46)	(46)
WATER PRODUCTION VERSUS T.H.L(SEE FIG NO.)	(44)	(44)	(44)



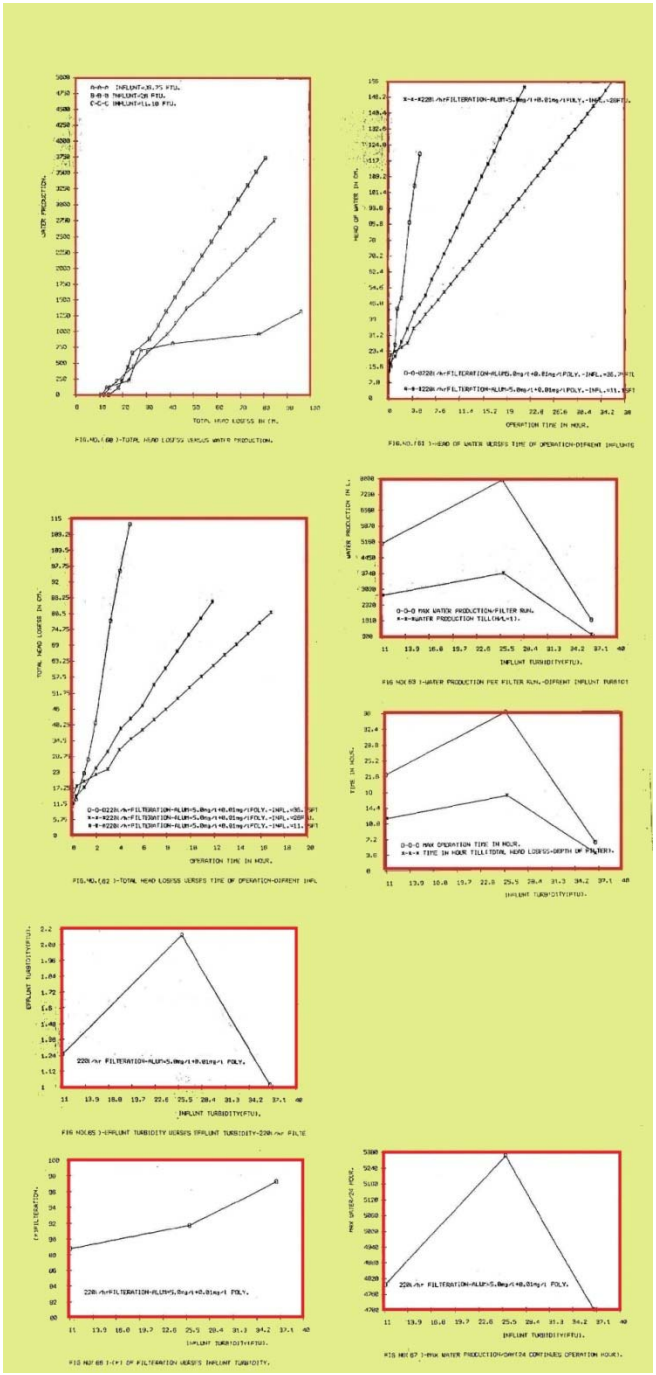
Third Group Test
Fixed filtration Rate
Coagulant: Alum 15.0mg/l Sand: Type 2
Depth of Filtration Media: 40cm
Aggregate layer: 10 cm

SPECIFICATION.	TEST NO.8	TEST NO.9	TEST NO.10
FILTER TYP	DUAL MED.	DUAL MED.	DUAL MED.
SAND TYP.	NO.2	NO.2	NO.2
SAND DEPTH IN CM.	40cm.	40cm.	40cm.
CRASHED BRICK TYP.	NO.1	NO.1	NO.1
BRICK DEPTH IN CM.	40cm.	40cm.	40cm.
GRAVIL DEPTH IN CM.	10cm.	10cm.	10cm.
FILTERATIN RATE.	220 L/HR	220 L/HR	220 L/HR
INFLUNT TURBIDITY.	9.1 FTU 70.06mg/l	39.5 FTU 462.9mg/l	21.87 FTU 235.1mg/l
EFFLOUNT TUBIDITY.	1.675FTU	1.668FTU	1.74FTU
EFFICIENCY(%)	81.56%	95.776%	92.044%
WATER TEMPRETURE.	19.6 C	16.2 C	17.6 C
PH	7.4 PH	7.4 PH	7.6 PH
COAGULANT.TYP.	ALUM	ALUM	ALUM
COAGULANT DOSE(mg/l)	15.0mg/l	15.0mg/l	15.0mg/l
VELOSITY GRADENT(G)	(51.2541)	(53.043)	(52.4577)
TIME FOR BACK WASH.	28 HR	14 HR	26 HR
TIME FOR TOTAL HEAD LOSSES =80 cm.	14 HR	10 HR	16 HR
TOTAL WATER PROD.	6202.66L	3340.8L	5223.75L
TOTAL WATER PROD.TIL T.H.L=80 cm.	3442.66L	2460.8L	3333.75L
T.H.L VERSUS TIME SEE FIG NO.	(54)	(54)	(54)
WATER LEVEL VERSUS TIME(SEE FIG NO.)	(53)	(53)	(53)
WATER PRODUCTION VERSUS T.H.L(SEE FIG NO.)	(52)	(52)	(52)



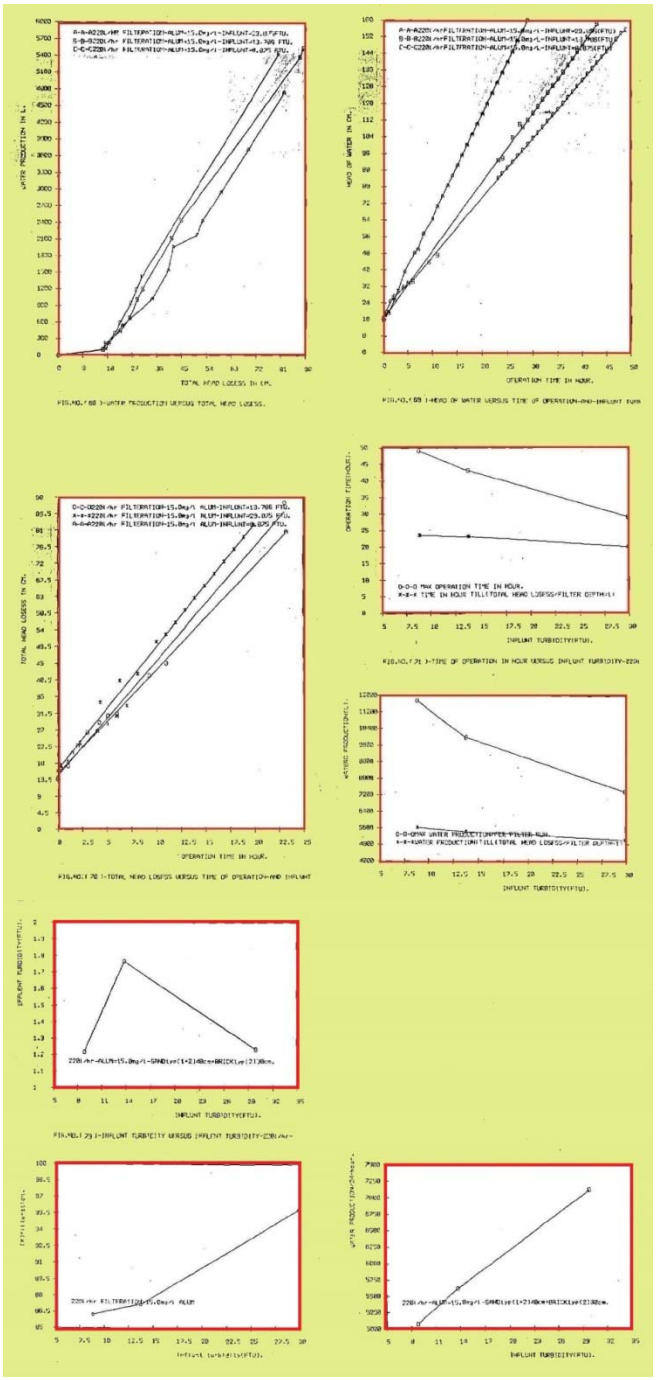
Forth Group Test
Fixed filtration Rate
Coagulant: Alum 5.0mg/l + polyelectrolyte 0.1mg/l
Sand: Type 2
Depth of Filtration Media: 40cm
Aggregate layer: 10 cm

SPECIFICATION.	TEST NO.11	TEST NO.12	TEST NO.13
FILTER TYP	DUAL MED.	DUAL MED.	DUAL MED.
SAND TYP.	NO.2	NO.2	NO.2
SAND DEPTH IN CM.	40cm.	40cm.	40cm.
CRASHED BRICK TYP.	NO.1	NO.1	NO.1
BRICK DEPTH IN CM.	40cm.	40cm.	40cm.
GRAVIL DEPTH IN CM.	10cm.	10cm.	10cm.
FILTERATIN RATE.	220 L/HR	220 L/HR	220 L/HR
INFLUNT TURBIDITY.	36.75 FTU 427.3mg/l	26.0 FTU 282.4mg/l	11.15 FTU 96.55mg/l
EFFLOUNT TUBIDITY.	1.02 FTU	2.15 FTU	1.25 FTU
EFFICIENCY(%)	97.22%	91.72%	82.78%
WATER TEMPRETURE.	11.1 C	12.3 C	9.8 C
PH	7.4 PH	7.4 PH	7.4 PH
COAGULANT.TYP.	ALUM+POL.	ALUM+POLY	ALUM+POLY
COAGULANT DOSE(mg/l)	5.0 ALUM+ 0.01 POLY	5.0 ALUM+ 0.01 POLY	5.0 ALUM+ 0.01 POLY
VELOSITY GRADENT(G)	(51.0398)	(50.5286)	(47.7903)
TIME FOR BACK WASH.	6 HR	36 HR	22 HR
TIME FOR TOTAL HEAD LOSSES =80 cm.	3.5 HR	17 HR	12 HR
TOTAL WATER PROD.	1632.25L	7924.833L	5086L
TOTAL WATER PROD.TIL T.H.L=80 cm.	964.8L	3744.833L	2766L
T.H.L VERSUS TIME SEE FIG NO.	(62)	(62)	(62)
WATER LEVEL VERSUS TIME(SEE FIG NO.)	(61)	(61)	(61)
WATER PRODUCTION VERSUS T.H.L(SEE FIG NO.)	(60)	(60)	(60)



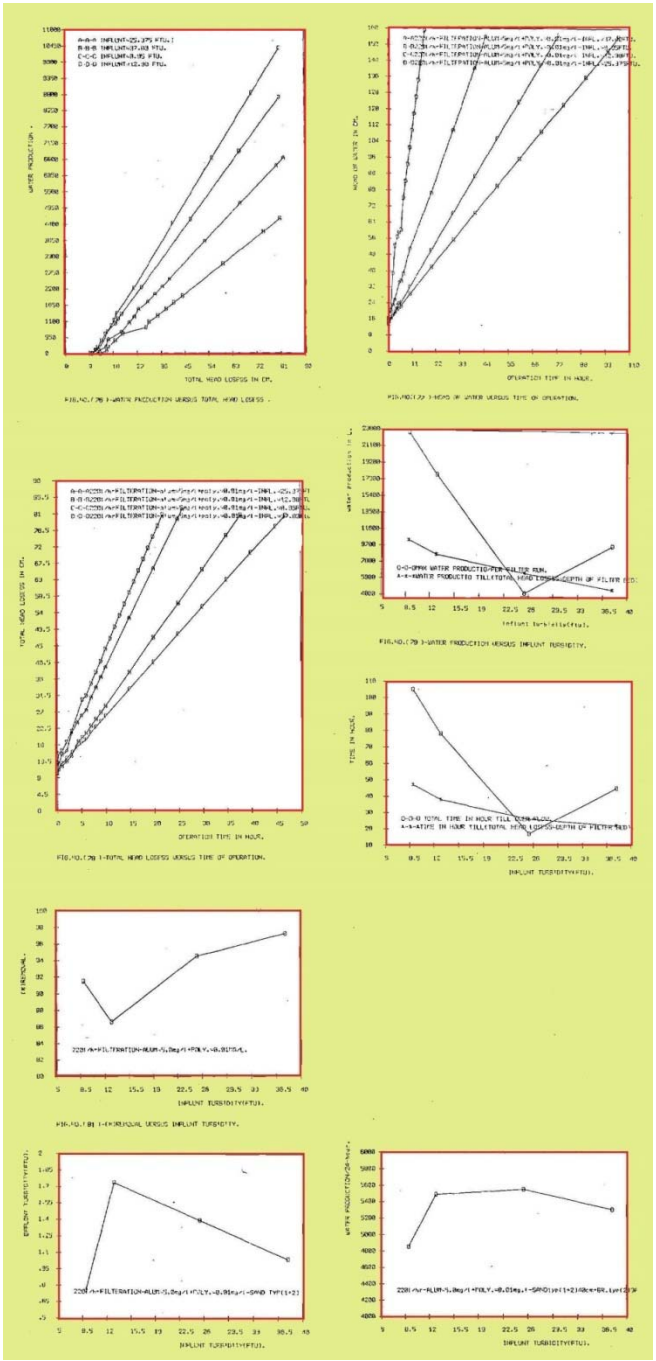
Fifth Group Test
Fixed filtration Rate
Coagulant: Alum 15.0mg/l
Sand: mixed Type 1+2(1:1)
Depth of Filtration Media: 40cm
Aggregate layer: 10 cm

SPECIFICATION.	TEST NO.14	TEST NO.15	TEST NO.16
FILTER TYP	DUAL MED.	DUAL MED.	DUAL MED.
SAND TYP.	NO.(1+2) (1:1)	NO.(1+2) (1:1)	NO.(1+2) (1:1)
SAND DEPTH IN CM.	40cm.	40cm.	40cm.
CRASHED BRICK TYP.	NO.2	NO.2	NO.2
BRICK DEPTH IN CM.	30cm.	30cm.	30cm.
GRAVIL DEPTH IN CM.	10cm.	10cm.	10cm.
FILTERATIN RATE.	220 L/HR	220 L/HR	220 L/HR
INFLUNT TURBIDITY.	15.786FTU 130.6mg/l	29.87FTU 338.5mg/l	8.875FTU 67.15mg/l
EFFLOUNT TUBIDITY.	1.765FTU	1.235FTU	1.217FTU
EFFICIENCY(%)	97.197%	95.86%	86.28%
WATER TEMPRETURE.	11.1 C	10.5 C	11.1 C
PH	7.4 PH	7.4 PH	7.4 PH
COAGULANT.TYP.	ALUM	ALUM	ALUM
COAGULANT DOSE(mg/l)	15.0mg/l	15.0mg/l	15.0mg/l
VELOSITY GRADENT(G)	(51.0959)	(51.3062)	(51.0398)
TIME FOR BACK WASH.	43 HR	29 HR	49 HR
TIME FOR TOTAL HEAD LOSSES =80 cm.	23 HR	20 HR	23.5 HR
TOTAL WATER PROD.	9933.6L	7360.3L	11749.25L
TOTAL WATER PROD.TIL T.H.L=80 cm.	5438.6L	5047.3L	5629.25L
T.H.L VERSUS TIME SEE FIG NO.	(70)	(70)	(70)
WATER LEVEL VERSUS TIME(SEE FIG NO.)	(69)	(69)	(69)
WATER PRODUCTION VERSUS T.H.L(SEE FIG NO.)	(68)	(68)	(68)



Sixth Group Test
Fixed filtration Rate
Coagulant: Alum 5.0mg/l + Polyelectrolyte 0.01mg/l Sand: mixed Type 1+2(1:1)
Depth of Filtration Media: 40cm
Aggregate layer: 10 cm

SPECIFICATION.	TEST NO.17	TEST NO.18	TEST NO.19	TEST NO.20
FILTER TYP	DUAL MED.	DUAL MED.	DUAL MED.	DUAL MED.
SAND TYP.	NO.(1+2) (1:1)	NO.(1+2) (1:1)	NO.(1+2) (1:1)	NO.(1+2) (1:1)
SAND DEPTH IN CM.	40cm.	40cm.	40cm.	40cm.
CRASHED BRICK TYP.	NO.2	NO.2	NO.2	NO.2
BRICK DEPTH IN CM.	30cm.	30cm.	30cm.	30cm.
GRAVIL DEPTH IN CM.	10cm.	10cm.	10cm.	10cm
FILTERATIN RATE.	220 L/HR	220 L/HR	220 L/HR	220 L/HR
INFLUNT TURBIDITY.	25.375FTU 280.4mg/l	12.98FTU 120.3mg/l	8.95FTU 68.1mg/l	37.83FTU 441.3mg/l
EFFLOUNT TUBIDITY.	1.575FTU	1.737FTU	0.755FTU	1.0417FTU
EFFICIENCY(%)	94.5%	86.62%	91.56%	97.25%
WATER TEMPRETURE.	11.4 C	11.8 C	11.2 C	11.6 C
PH	7.4 PH	7.4 PH	7.4 PH	7.4 PH
COAGULANT.TYP.	ALUM+POLY	ALUM+POLY	ALUM+POLY	ALUM+POLY
COAGULANT DOSE(mg/l)	5.0 ALUM+ 0.01 POL.	5.0 ALUM+ 0.01 POL.	5.0 ALUM 0.01 POL.	5.0 ALUM+ 0.01 POL.
VELOSITY GRADENT(G)	(50.9094)	(50.7302)	(50.9961)	(50.8234)
TIME FOR 'BACK WASH.	17 HR	78 HR	105 HR	45 HR
TIME FOR TOTAL HEAD LOSSES =80 cm.	25 HR	38 HR	47 HR	22 HR
TOTAL WATER PROD.	4340L	17906.7L	22672.7L	9918.5L
TOTAL WATER PROD.TIL T.H.L=80 cm.	6653L	8706.7L	10352.6L	4858.5L
T.H.L VERSUS TIME SEE FIG NO.	(78)	(78)	(78)	(78)
WATER LEVEL VERSUS TIME(SEE FIG NO.)	(77)	(77)	(77)	(77)
WATER PRODUCTION VERSUS T.H.L(SEE FIG NO.)	(76)	(76)	(76)	(76)



XIII. Results

1. Suggestion of the use of crashed brick, washed perfectly to clean away all salts that might be within the brick materials, and sieved to have homogenous particles.
2. All tests indicate the possibility of using crashed bricks as top layer in gravity multimedia filtration,
3. Increasing efficiency through proper control of mixing, turbidity, filtration rate and velocity gradient.
4. Experimental filtration gives V.good Results for filter working cycle" filtration cycle increased to at least twice ", and quantities of water production& Quality.
5. Labs tests shows a positive results on removing TDS within the supplied water.
6. It is recommended to Use Polymer with Alum for Coagulation for better Results.
7. Filtration efficiency up to 98% at laboratory Tests. When using the proposed crashed brick as first layer.
8. Minimum depth of sand media is calculated to be 20 cm.
9. It is important to check Coagulant potential value to have better Results.
10. Crashed bricks have to be replaced with new layer after approximate 60 cleaning cycle.

11. Tests also indicate that there will be intermediate layer between cashed brick and the top sand layer : this layer will be a mixed of proposed crashed brick with top fine sand , the tests also indicate that this layer will be about 10 cm in thickness:.
    Results of experimental tests indicate the efficiency of filtration increased up to crashed brick layer of 40 cm, then the efficiency droped. According to this information the sand layer is fixed to be 40 cm and the crashed brick layer type-1 is fixed to be 40 cm during the following experimental tests.
12. Specific coefficient "Segma " value is calculated to be "ranged from 0.015 to 0.135 ,see attached figure
13. The increase of deposit inside the filter media with time will cause continues change in filter porosity; below figures indicate these changes for different type of filter media.
14. Coefficient of permeability increased in value when head losses ratio decreases. Attached figure shows this elation for different type of filter media.
15. Production of water with reference to deposit parameters. This relation theoretically should be linear, but experimental tests give parabolic elation due to : at the beginning of filtration cycle the filter media is clean and the deposit will be settled within the porosity randomly ,with time the deposit will be more regular, this unsymmetrical relation is due to the value of "beta"
16. Relation between maximum water production can be achieved theoretically compared with real water production are shown below, maximum percentage is 74% , from group test NO.1.
17. Results also indicates the advantages of using valuable filtration rate compared with fixed rate filtration ",filtration rages from 3.6 to 14.0 m3/m2/hr".
18. All gravity filters have its own standard coefficient which is called filtration coefficient "lumda". during those experimental test we tried also to calculate the values of this coefficients" which ranged from 1 to 0.66 "

XIV. Recommendation

Only crashed brick is used in this study, it is highly recommended to check the possibility of crashed stone, crashed concrete, and even palm tree leaf.

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Global Journal of Researches in Engineering: E
Civil And Structural Engineering
Volume 16 Issue 3 Version 1.0 Year 2016
Type: Double Blind Peer Reviewed International Research Journal
Publisher: Global Journals Inc. (USA)
Online ISSN: 2249-4596 & Print ISSN: 0975-5861

Reliability Analysis of Timber Roof Truss Systems using Genetic Algorithm

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Abstract- Structural reliability analysis was carried out on the *Mansonia altissima* timber, to ascertain its structural performance in timber roof truss system. Structural analysis of the timber truss was in accordance with Eurocode 5 (2004) and was carried out under the Ultimate Limit State of loading. A developed MATLAB (2010) programme was employed for reliability analysis of the timber roof truss of *Mansonia altissima* timber so designed, to ascertain its level of safety using GA-based First-Order Reliability Method. The uncertainties in the strength and load variables were accommodated in the reliability analysis. The result of the analysis revealed that the Joint failure mode is the critical safety index that is minimum safety index among the failure modes of the truss under the design conditions. The *Mansonia altissima* timber was found to be a satisfactory structural element for timber roof truss at depth of 75mm, breadth of 50mm and under the ultimate limit state of loading with the corresponding of 2.58. Sensitivity analysis proves that the degree of reliability of the timber roof truss can be improved if cross-sections of species, diameter of nail at joint, pitch of truss and loadings are suitable selected.

Keywords: *reliability analysis, GA-based form, roof truss, failure modes, mansonia altissima.*

GJRE-E Classification : *FOR Code: 090506*

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I. Introduction

The traditional way of dealing with uncertainties in design process is to use conservative values of the uncertain quantities and/or safety factors in a deterministic approach. The shortcomings of this approach may become more obvious when designing for loads with very high variability. It is not easy to account for all factors that affect assessment of loads consistent with acceptable risk (Anthony, 1991; Afolayan, 1999 and Abubakar and Mohammed, 2011). However, since no structure may be free from the possibility of failure, loads must be designed to fit the risk. A deterministic design approach does not an explicit consideration for this. A more meaningful treatment of uncertainties in structural timber can be through a probability-based design philosophy, which has received considerable attention (Afolayan, 2005; Abejide, 2006; Ahmed *et al.*, 2010,; Kachalla and Kolo, 2012; Aguwa, 2013; Ditlevsen and Madsen, 2005).

The tensile and compressive properties of the timber are particularly important when applying timber as structural components such as roof trusses (Ahmad *et al.*, 2010). The tensile strength of the lower chord of a truss is considered the critical design parameter (Bostrom *et al.*, 1999). It had been identified that joints in timber structures are the most critical components that need special extensive research (Racher, 1995; Smith and Foliente, 2002; Riley and Sadek, 2003). According to Frank and Philip (1997), bottom chord joints are located in areas such that they experience a small bending moment, and are stressed primarily in tension. He determined the steel net section capacity of bottom chord joints of wood trusses subjected to tension and moment loading.

Genetic algorithm is intelligent search and optimization method that work very similar to the principles of natural evolution called Darwin's survival-of-the fittest principles. If GA is incorporated in to reliability methods such as FORM, population of limit functions with different combination design variables are considered, and safety index is obtained for each set. The sets of safety index are assembled and the minimum that is the globally best and fittest is considered. Several generations are further considered through crossover, mutation and elitism operation in GA until a convergent is achieved. This widen the search space for the global minimum (critical) safety index (Mohammed and Abubakar, 2011; Cheng, 2007; Wang and Ghosn, 2005).

II. Limit State Functions

The Eurocode 5 design criteria of roof truss members subjected to combination of varying design actions are briefly reviewed. Identification of the significant failure modes was deterministically analysed and of failure modes (tension, compression, bending of the top and bottom chord) were established.

a) Structural model

The analysed structural model of the truss system is shown in Fig. 1. It was assumed that the truss had a roof pitch of 35^0, spacing between the trusses of 1.2 m, Length of 7.2 m, dead load of 0.55 kN/m^2, fixed nailed length of 90 mm, nail diameter of 4.0mm and dead-to-live load ratio of 0.275. The roofing material used was aluminium-roofing sheets. The connections between the members were assumed to be pinned joints as stipulated in Eurocode 5 (2004).

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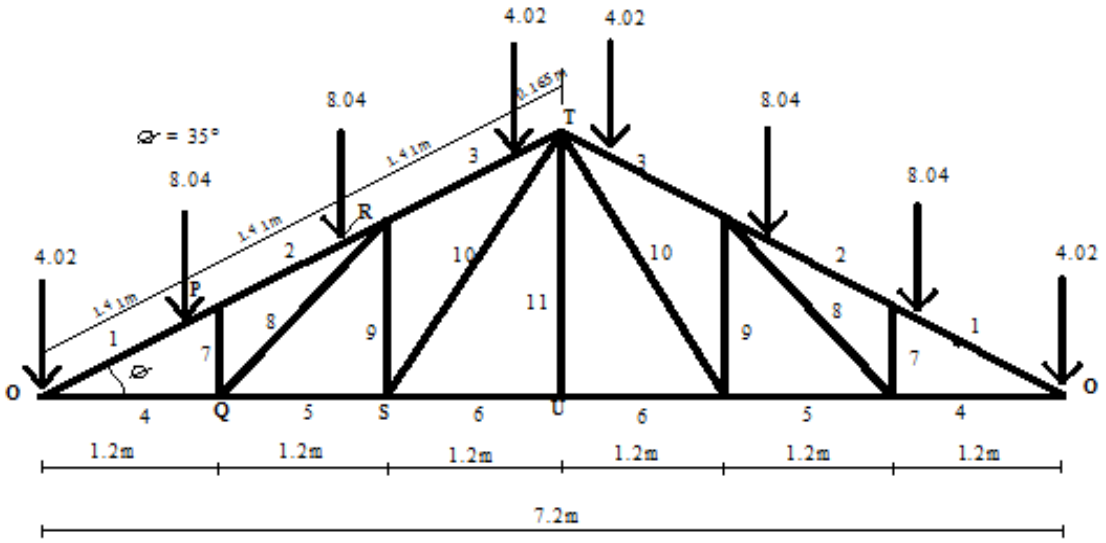

Fig. 1 : Typical truss subjected to nodal design loadings

The following limit state functions were established from the structural analysis of the model.

i. *Compression failure criterion*

The limit state function for compression is given as:

$$G(x)=\frac{(k_{mod}f_{c,0,k})}{\gamma_m}-\sigma_{ci,d} \quad (1)$$

where k_{mod} is modification factor for variation in density and moisture content. $f_{c,0,k}$ is the characteristic compressive strength parallel to grain. γ_m is the timber material partial safety factor for strength, $\sigma_{ci,d}$ is the design compressive stress for members under compression that are members 4, 5, 6, 8 and 10.

ii. *Tension failure criterion*

The limit state function for tension is given as:

$$G(x)=\frac{(k_{mod}f_{t,0,k})}{\gamma_m}-\sigma_{ti,d} \quad (2)$$

where $f_{t,0,k}$ is the characteristic tensile strength parallel to grain, $\sigma^{ti,d}$ is the design tensile stress for members under tension that are members 1, 2, 3, 7, 9 and 11.

iii. *Bending failure criterion*

The following is the limit state function for bending is as following:

$$G(x)=\frac{(k_{mod}f_{m,k})}{\gamma_m}-\sigma_{mi,d} \quad (3)$$

$f_{m,k}$ is the characteristic bending strength, $\sigma_{mi,d}$ is the design bending stress for members under bending that include member 1, 2, 3, 4, 5, and 6.

iv. *Connection failure criterion*

The EC5 (2004), defines the characteristic load-carrying capacity for nailed joints per shear plane per fastener (R_k), at the specified minimum spacing should be the minimum value from the following expressions:

$$R_k=\min\begin{cases} f_{h..1.k}t_1 d \\ f_{h..2.k}t_2 d \\ \frac{f_{h.1.k}t_1 d}{1+\theta}\left[\sqrt{\theta+2\theta^2\vartheta+\theta^3T^2}-\theta(1+T)\right] \\ \frac{f_{h.1.k}t_1 d}{2+\theta}\left[\sqrt{2\theta(1+\theta)+\frac{5\theta(1+2\theta)M_{yk}}{f_{h.1.k}dt_1^2}}-\theta\right] \\ \frac{f_{h.1.k}t_2 d}{1+2\theta}\left[\sqrt{2\theta^2(1+\theta)+\frac{5\theta(1+2\theta)M_{yk}}{f_{h..1.k}dt_2^2}}-\theta\right] \\ 1.15k_{cal}\sqrt{\frac{2\theta}{1+\theta}}\sqrt{2M_{yk}f_{h.1.k}d} \end{cases} \quad (4)$$

where $\theta=\frac{f_{h.2.k}}{f_{h.1.k}}$, $T=\frac{t_2}{t_1}$, M_{yRk}, $f_{h.1.k}$, *and* $f_{h.2.k}$ are the yield moment and embedding strength corresponding to head side (t_1) and point side (t_2) timber thickness respectively, d being the nail diameter.

Eurocode 5 (2004) recommends that the value of k_{cal} should be 1.3 and 1.5 for smooth nails of round, square or groove cross sections, and threaded nails respectively.

The characteristic values for high yield moment using round wire nail can be deduced from the following expression:

$$M_{y.k} = \frac{f_u}{600} 180 d^{2.6} \quad (5)$$

The limit state formulation for the nail joint only is given as

$$G(x) = \frac{n(K_{mod})R_k t_i}{\gamma_m} - S \quad (6)$$

where S is the load effect in member; K_{mod} is the composite modification factor taking into account deviations from normal load and climate conditions during the service life; γ_m, is partial safety factor for the material (1.3); n is number of fasteners; t_i is depth of the timber species .

The statistics of the design variables employed in the study suitable for targeted performance levels are shown in Table 1.

Table 1 : Stochastic model of design variables

Variable	Coefficient of Variation	Distribution Model
Bending strength (N/mm^2)	15	Lognormal
Modulus of Elasticity (N/mm^2)	13	Lognormal
Density (kg/m^3)	10	Normal
Dead load, G_k	10	Normal
Imposed load, Q_k	25	Gumbel
Load duration factor, k_{mod}	15	Lognormal
Model uncertainty (load), Θ_S	10	Lognormal
Model uncertainty (strength), Θ_R	10	Lognormal
Diameter of nail	10	Normal
Depth of timber species	6	Normal

(Source: Ellingwood et al, 1980; Bartlett et al, 2003; Ranta-Maunus, 2004; Afolayan, 2005; Andre and Antonio, 2010; Aguwa,2013)

III. Structural Reliability Analysis

Analysis is aimed at a systematic consideration of the variability in the design variables. Assuming u is an independent, standard normal vector containing the parameters of the stress-strength interference and g(u) the state function representing the interference then according to Afolayan (2005) a measure of violation of such a state is

$$P_f = P(u \in F) = P(g(u) \leq 0) \quad (7)$$

where F is the failure domain. Equation (1) can be approximated to give (Gollwitzer et al., 1988; Padmanabhan, 2003):

$$P_f \approx \Phi(\beta) \quad (8)$$

The GA for reliability analysis can be formulated in the following form (Cheng, 2007):

$$Minimize\ \beta = \|\mu\|^2 = \mu^T.\mu \quad (9)$$

The convergence is achieved using the following condition;

$$\beta_{average}^{(k+1)generati\ on} > \gamma_{average}^{kgeneration} \quad (10)$$

where γ can be set to 0.95 (Wang and Ghosn, 2005).

IV. Results and Discussion

The force and stress in each member due to action loads was determined using resolution of forces. The critical load at each joint was used in the analysis of the joints. The member-force, member-stress and formulated model function for each member as presented in Table 2 were used in the reliability analysis.

Table 2 : Member-Force and Member-Stress Model Function

Member	Model Function	
	F(x)	σ_i
1 (T)	$7.56l_i(0.9\alpha + 1)$	$\frac{7.56l_i(0.9\alpha + 1)}{bt}$
2 (T)	$7.56l_i(0.9\alpha + 1)$	$\frac{7.56l_i(0.9\alpha + 1)}{bt}$
3 (T)	$5.46l_i(0.9\alpha + 1)$	$\frac{5.46l_i(0.9\alpha + 1)}{bt}$

4 (C)	$6.24l_i(0.9\alpha+1)$	$\frac{6.24l_i(0.9\alpha+1)}{bt}$
5 (C)	$4.92l_i(0.9\alpha+1)$	$\frac{4.92l_i(0.9\alpha+1)}{bt}$
6 (C)	$2.84l_i(0.9\alpha+1)$	$\frac{2.84l_i(0.9\alpha+1)}{bt}$
7 (T)	$1.52l_i(0.9\alpha+1)$	$\frac{1.52l_i(0.9\alpha+1)}{bt}$
8 (C)	$2.14l_i(0.9\alpha+1)$	$\frac{2.14l_i(0.9\alpha+1)}{bt}$
9 (T)	$4.12l_i(0.9\alpha+1)$	$\frac{4.12l_i(0.9\alpha+1)}{bt}$
10 (C)	$5.64l_i(0.9\alpha+1)$	$\frac{5.64l_i(0.9\alpha+1)}{bt}$
11 (T)	$3.64l_i(0.9\alpha+1)$	$\frac{3.64l_i(0.9\alpha+1)}{bt}$

where (T) and (C) represent tension and compression members respectively, l_i is the length of member, α is the dead-to-live load ratio, b is breadth and t is depth of timber species.

The result of the reliability analysis of the roof truss for *Mansonia altissima* at the ultimate state of loading was presented in Table 3. The safety indices for the bending, tension, compression and joint failure modes are 3.94, 2.92, 3.62 and 2.58 respectively. Joint failure mode is the least failure mode hence predetermines the safety of the truss. The computed critical safety index of 2.58 agrees with Melchers (1987) who stated that target reliability index (β_T) for timber members ranges from 2.0 to 3.0 with strong mean of 2.5. This implies that at this depth of section the timber roof truss is reliable under specified conditions of loadings and geometric properties. However, the degree of reliability of the roof truss can be improved if suitable cross-section is chosen (Benu and Sule, 2012). The sensitivity analysis was conducted to ascertain the effect of some of design variables on the reliability of the truss.

Table 3 : Safety Indices for the timber roof truss of *Mansonia altissima*

Failure mode	Safety index
Bending	3.94
Tension	2.92
Compression	3.62
Joint	2.58

Fig. 2 shows the relationship between safety index (β) and depth of section (t) for the timber roof truss of Mansonia *altissima*. An increase in safety index (β) from 1.96 to 4.47 was recorded for joint failure mode as the depth was increased from 50mm to 250mm respectively. The Joint failure mode has the least safety index among all the failure criteria for the *Mansonia altissim*a then followed by tension failure mode as shown in Fig. 2 The increase in safety index (β) could be attributed to the increase in EI values, which increased the rigidity of the section (Aguwa, 2013). It is worthy to note that at a larger depth, the structure may be very reliable but not economical because drying and lifting will be a problem. Since structural safety must recognize financial burden involved in project execution and general utility, the derived factors of safety are improved to balance conflicting aims of safety and economy (Afolayan, 1999).

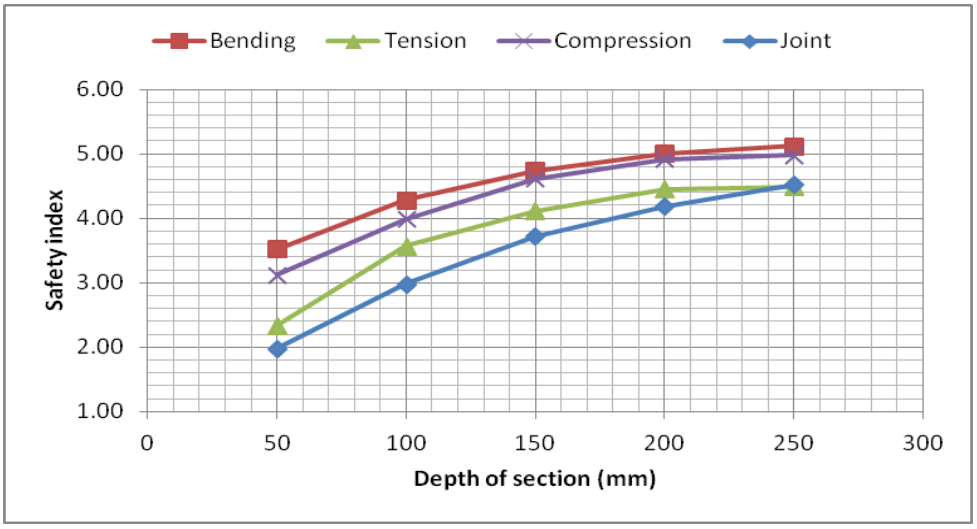

Figure 2 : Variation of safety index against depth of section for *Mansonia altissima*

Fig. 3 shows the relationship between depth of section and live load for the timber roof truss of Mansonia *altissima* at the ultimate limit state of loading and at variable live load. An increase in the depth of section was recorded for all the failure modes as the live increases. The result revealed that Joint failure mode is predominant which recorded an increase in the depth of section from 105mm to 157mm as the live increases from 1.0kN/m to 7.0kN/m respectively. This implies that live load has significant effect on the design depth of the roof truss members of *Mansonia altissima*.

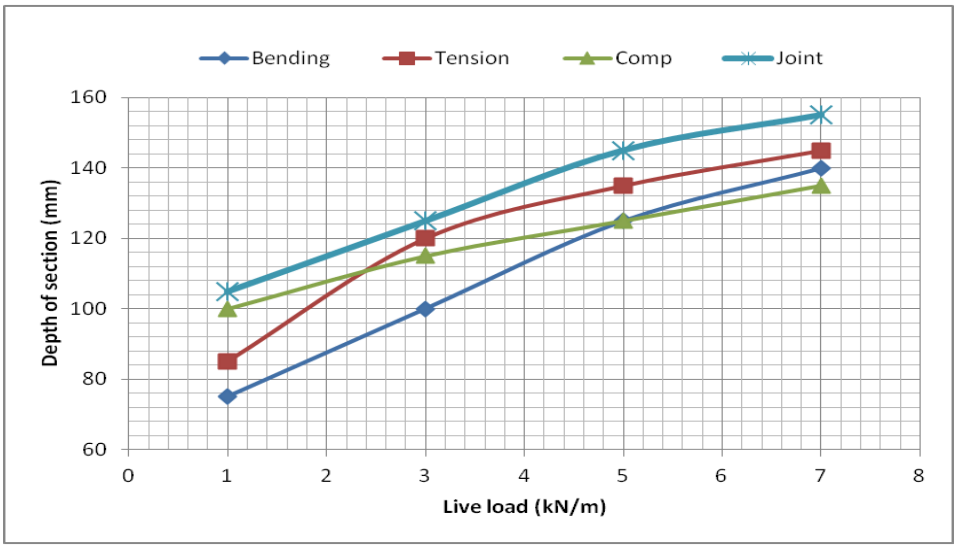

Figure 3 : Variation of depth of section with live load for *Mansonia altissima*

At live load of 1.0kN/m, the bending and compression failure modes recorded the depth of sections of 75mm and 100mm respectively. As the live load increased to 5.0kN/m, the depth of sections for bending and compression converged to an approximate depth of section of 125mm. This implies that there are overlaps of behaviours among the truss members at different live loads.

Fig. 4 shows the relationship between safety index and live load for timber roof truss of *Mansonia altissima* at the ultimate limit state of loading and at variable live load. A decrease in safety index (β) was recorded for all the failure modes with joint failure mode been predominant then followed by tension failure mode. A general consistent decrease in safety index was recorded for joint failure mode from 4.12 to 1.23 as the live load was increased from 1.0kN/m to 7.0kN/m respectively. This could be attributed to the increase in EI values, which increased the rigidity of the beam (Aguwa and Sadiku, 2012). The members of the roof truss for *Mansonia altissima* is safe at a minimum breadth of 50mm under the specified design conditions.

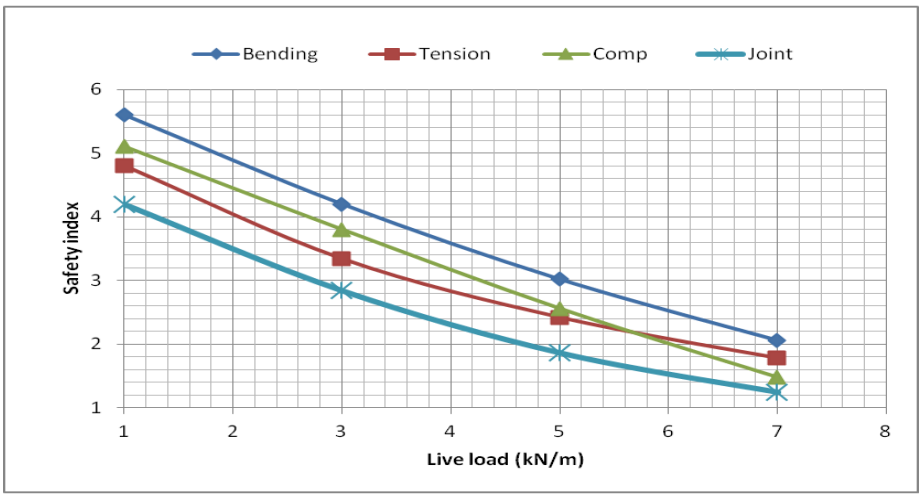

Figure 4 : Variation of depth of section with live load for *Mansonia altissima*

Fig. 5 shows the relationship between safety index and diameter of nail at joint for the timber roof truss of *Mansonia altissima* at the ultimate limit state of loading. An increase of safety index was recorded from 3.98 to 4.4 as the diameter of nail increases from 3mm to 5mm. The safety index then declined to 4.08 at 7 mm. This indicates that at the peak value of safety index the timber species reached its highest capacity to resist the effect of diameter of nails and thus hold the timber pieces firmly together, but beyond this critical diameter of nail the timber species have less resistant capacity to withstand any increase in stresses due to increase in diameter of nails. It therefore tends to split. To avoid this split of timber piece EC 5 (2004) recommends pre-drilling of holes for large diameter of nails.

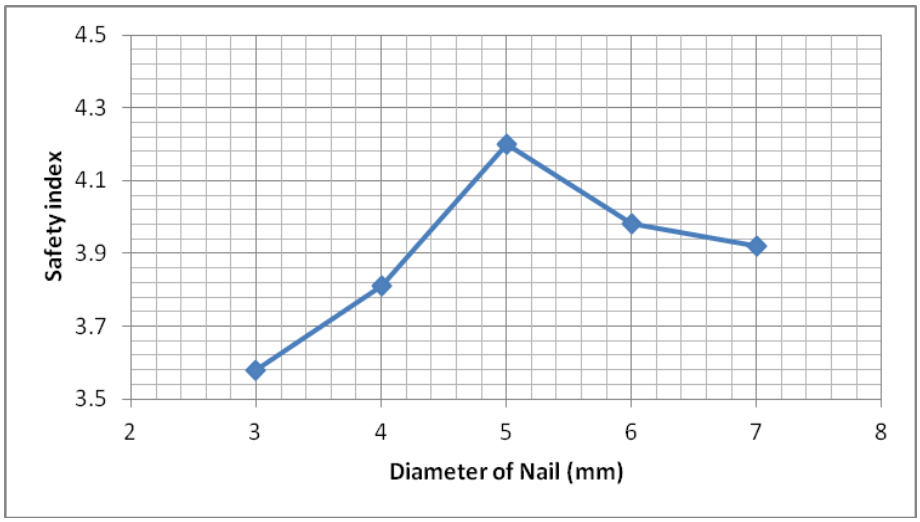

Figure 5 : Variation of safety index with diameter of nail

Fig. 6 shows the relationship between safety index and depth of section at various pitches of the timber roof truss of *Mansonia altissima* at the ultimate limit state of loading. An increase in safety index (β) was recorded for all the failure modes at various pitches of the truss with joint failure mode been predominant then followed by tension failure mode. It was observed that the pitch of the truss has significant effect on safety of the timber roof truss. Considering joint failure mode an increase in safety index (β) was recorded from 1.25 to 3.81 as the depth of section of timber members increases 50mm to 250mm at the pitch of 10^0 respectively. However, as the pitch increases to 20^0, the safety index significantly increases from 1.94 to 4.32 at the same ranges of the depth of section. This implied that for a pitched roof truss large rafter slope lead to high reliability.

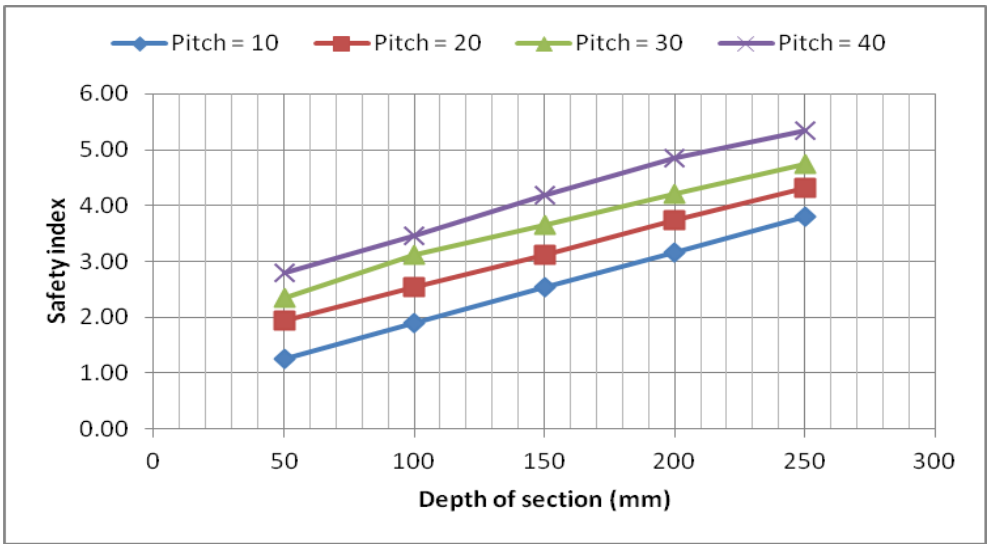

Figure 6 : Safety index against depth of section for various pitches

V. Conclusion

This paper has presented a reliability analysis of the timber roof truss using GA-based FORM, which searches for the globally best and fittest solution. The failure modes of truss were checked and the uncertainties in the strength and load variables were accommodated in the reliability analysis. It is shown that the M*ansonia altissima* timber species is a reliable structural material and economical for the roof truss system at the specified ultimate state of loading and geometrical parameters. The sensitivity analysis revealed that the safety index (β) is highly sensitive to the depth of section, dead-to-live load ratio, diameter of nail and pitch of truss; hence, they are the critical factors to be considered in design of timber roof truss.

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Global Journal of Researches in Engineering: E
Civil And Structural Engineering
Volume 16 Issue 3 Version 1.0 Year 2016
Type: Double Blind Peer Reviewed International Research Journal
Publisher: Global Journals Inc. (USA)
Online ISSN: 2249-4596 & Print ISSN: 0975-5861

Application of Initial Value Model in Circular Cylindrical Shell Analysis

By Mbanusi E. C., Obodoh D. A., Ezeokonkwo J. U., Ogunoh P. E. & Okolie K. C.

Nnamdi Azikiwe University

Abstract- This study simulated underground circular cylindrical shell structure to serve as water reservoir under known soil characteristics and conditions. Cognizance of prevailing acute scarcity of portable water supply, more often than not, during each year, this structural facility was also simulated for study under two distinct situations namely: when it is empty and when it is full of water. Structural analysis of the facility was carried out using the initial value model whereas the classical model served to establish validity. The study sought the stress effect arising from: empty condition and in full of water, on this facility. The investigation result revealed: Both classical and initial value models led to identical results. Effect of stress which resulted from the two different conditions did not diminish the structural integrity of this facility.

Keywords: *asymptotic integration, axi-symmetric, cylindrical shell, hoop tension, thin-walled structures.*

GJRE-E Classification : *FOR Code: 090599*

Strictly as per the compliance and regulations of :

Application of Initial Value Model in Circular Cylindrical Shell Analysis

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Abstract- This study simulated underground circular cylindrical shell structure to serve as water reservoir under known soil characteristics and conditions. Cognizance of prevailing acute scarcity of portable water supply, more often than not, during each year, this structural facility was also simulated for study under two distinct situations namely: when it is empty and when it is full of water. Structural analysis of the facility was carried out using the initial value model whereas the classical model served to establish validity. The study sought the stress effect arising from: empty condition and in full of water, on this facility. The investigation result revealed: Both classical and initial value models led to identical results. Effect of stress which resulted from the two different conditions did not diminish the structural integrity of this facility.

Keywords: asymptotic integration, axi-symmetric, cylindrical shell, hoop tension, thin-walled structures.

I. Introduction

Shell [1] is applied to bodies bounded by two curved surfaces, where, the distance between the surfaces is small in comparison with other body dimensions. The centre of points lying at equal distances from these two curved surfaces defines the middle surface of the shell. The lengths of the segment, which is perpendicular to the curved surfaces, is known as the thickness of the shell and is denoted by h. Shells have all the characteristics of plates, along with an additional one, which is curvature. Mindful of intrinsic, functional essence of shells, [2] presents shells as skin structures by virtue of their geometry and shell action, is essentially more towards transmitting the load by direct stresses with relatively small bending stresses. In line with this functional essence of the shell, [3], [15], shells are spatially curved surface structures which support applied external loads or forces. Shell structures [3], [5], [7] can be referred to as "form resistant structures". This implies a surface structure whose strength is derived from this shape, and which resists loads by developing stresses in its own plane [3], [5], [7].

An early form of shell construction [6] was the dome known to Romans thousands of years ago. With shell concrete construction, [6] it becomes quite possible to produce satisfactory domes which weigh only a fraction of the weights of the much earlier massive domes.

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Properties of shells [1], [5] which are of particular importance in structural usage and which also earn wide application of shell structures in engineering are the following: (i) Efficiency of Load carrying behavior; (ii) High degree of reserved strength and structural integrity; (iii) High strength versus weight ratio; (iv) Very high stiffness; (v) Containment of space.

Areas where shell structures [1], [4] are used in Building and Civil Engineering are:- (i) Large-span roofs; (ii) Liquid retaining structures and water tanks; (iii) Containment shells of nuclear power plants; and (iv) Concrete arch domes. Shell forms in Mechanical Engineering [1], [4] are used in: (i) Piping systems; (ii) turbine disks; (iii) Pressure vessels technology. The use of shells [1], [4] in aeronautical and marine engineering are in the following forms:- (i) aircrafts; (ii) missiles; (iii) rockets; (iv) ships; and (v) submarines. Shells [8] found in various biological forms such as the eye, the skull and the egg, represent another application of shell engineering, this time, in the field of biomechanics. An egg, as a natural thin-walled structure, can be considered as one of the most beautiful structural shapes. It combines extreme fitness for its purpose with an economy of material and cleanliness of design. This account depicts only a small list of shell forms in engineering and nature.

There are [1], [8] two different classes of shells: thin and thick shells. Shells are said to be thin when the ratio of their thickness, h, to the radius of curvature R of the middle surface is less than or equal to 1/20, i.e. $h/R \leq 1/20$. For a large number of practical applications [1], the thickness of thin shells lies within the range: $1/100 \leq h/R \leq 1/20$. Hence, shells for which these h/R stipulations do not lie within the stated range, belong to thick shells [1].

Thin plates and thin shells belong to a category of structures known as Thin-Walled Structures. Thin-walled structures [9] possess the following three characteristics: (i) two dimensions are much longer than the third, its thickness; (ii) They have a great strength as a result of their spatial character of working under the action of external loads; (iii) They make use of a minimal quantity of material.

Depending on the curvature of the surface [1], [3], shells are divided into (i) cylindrical, comprising of noncircular and circular; (ii) conical; (iii) spherical (iv) ellipsoidal; (v) paraboloidal; (vi) toroidal; and (vii) hyperbolic paraboloidal shells.

The usual theory of thin shells utilizes the main suppositions of the theory of thin plates. Nonetheless, thin plate and thin shell have a substantial difference in behaviour under external loadings. The static equilibrium of a plate element under lateral load [2], [8] is only possible by the action of bending and torsional or twisting moments, usually accompanied by shearing forces. Conversely, a shell, in general, [10] is capable of transmitting the surface load by "membrane" stresses uniformly distributed over its thickness. This property of shells [8], [10] makes them to be not only more economical but also more rigid than plates and other types of construction under the same conditions. Apart from these obvious advantages over other systems [1], [8], shell structures are very well known and used for their performance, strength against accidental damage, resistance to fire and low upkeep cost as well as their aesthetic appearance.

The economy and/or feasibility of many modern constructions necessitate light weight, a property which thin-walled structures are replete with. Strictly speaking, the aim in structural engineering has always been to lower, as much as possible, the cost and thus the quantity of material used without, compromising the structural integrity of the system. Thin-walled structures meet this requirement.

The deliberate effort in the analysis and design of shells [3] is to make the shell as thin as practical requirements would permit, so the dead weight is reduced and the structure functions as a membrane free from the large bending stresses.

Thin shell concrete structures [3] are pure compression structures formed from inverse catenary shapes. The inverse catenary is a pure compression scenario. Pure compression is ideal for concrete, as concrete has high compressive strength and very low tensile strength. These shapes maximize the effectiveness of concrete, allowing it to form thin light spans [3].

This paper presents the application of initial value model in analysis of underground circular cylindrical shell structure subject to axi-symmetrical loads of hydrostatic pressure but considered under two conditions: (i) when the tank is empty; (ii) when the tank is full. In addition, the paper seeks validity through the classical model.

Aim in this study is to investigate stress effect on the underground cylindrical shell structure when full of water as well as when empty. The study intends to achieve the aim through the following objectives:

1) To solve the governing differential equation of equilibrium of cylindrical shells subjected to radially symmetrical loads using both initial value and classical models.
2) To evaluate the five internal stresses of the underground cylindrical shell structure when full of water, using the two models named above.
3) To determine the five internal stresses of the underground cylindrical shell when empty, also using the same two models.

II. Previous Works

The analysis and design of shells attracted many researchers. Among them, perhaps the best known, are: Love, U. F., Pasternak, P. L. and Timoshenko, S. P. [11].

a) The Membrane Theory

Modern shell construction [11] has its origin in the work of Lame and Clopeyron who, in 1826, proposed the membrane analogy. This theory suggests that a shell is capable of resisting external loads by direct stresses called membrane stresses without bending. Hence, when membrane theory is applied for shell design, torsional or twisting, bending moments, and shear forces in the cross-section are neglected. This is only possible if torsion and bending stresses were small compared to stresses of normal or axial, and shear forces. Membrane theory fails to represent the true stresses in those portions close to the edges, since the edge conditions usually cannot be completely satisfied by considering only membrane stresses. It is expected [12] that membrane theory gives an approximate picture of stress distribution in the case of shells not long, say $L \leq 2R$, where R is radius of the shell and L is its length. For longer shells a satisfactory solution can be obtained only by considering bending as well as membrane stresses [12].

b) The Moment Theory

Mathematical conceptions [6], developed during the 19th century, made possible a more accurate analysis than could be achieved using any membrane theory. Aron, H., who derived an expression for potential energy of a shell as well as equations for shell equilibrium and strains, was the first to consider the new theory, evolved from those mathematical conceptions, which made room for both membrane and bending stresses [11].

Love [13] developed a detailed derivation of equilibrium equations and equations of motion of shells with correction to a number of slips in Aron's original treatment as analogous to the theory of plates of Kirchhoff [14], and was based on identical assumptions. In each particular case, the moment theory involves the solution of a system of three differential equations, which is very complicated.

c) The Semi-Moment Theory

In the 20th Century, [15] suggested a simplified method of analyzing and designing cylindrical shells using the theory of semi-moment. This theory, on the basis of experimental data concerning medium length cylindrical shells, length/diameter = 2 – 8, neglects the effect of longitudinal bending moment, shear forces and

torques, and introduces geometrical hypothesis. This method has the advantage to be simpler than the moment theory and gives accurate solution when a distributed load is applied. This paper admires this method for the simple reason it appears to be the most appropriate for circular cylindrical shell loaded symmetrically with respect to its axis – the axi-symmetric loading scenario.

Detailed information on general thin-walled structure theory were given in many general treatises such as: [9], [8] and [16], as well as monographs: [10], [17], [18], and [19]. These consider, in a great extent, the mathematical theory of thin-walled structures and the derivation of differential equations pertaining to them. Furthermore, the possibility of solving various shell-theory problems using analytic methods, has also been discussed in: [25], [26], [27], [28], [29], [30], [31], [32], and [33].

d) Methods of Solution

As far as techniques of solving the derived differential equations are concerned, difficulties involved in realizing mathematically rigorous methods, led to approximate techniques of integrating equilibrium equations. One of such methods, known as asymptotic integration, consists in replacing a given differential equation by another with specially selected coefficients different from those in the exact equation, and whose solution can be obtained by strict method and expressed in elementary functions. Blumenthal [20] suggested the method in 1912. In 1913, Timoshenko [21] applied it to shell equations. Shtayerman, Novozhilov [8], and Gol'denveiser [22] perfected the same asymptotic integration method.

Another widely accepted method was a version of the membrane theory which takes boundary effects into cognizance. Geckeler's equations [23] replaced exact equations owing to the presence of boundary effect. Generally speaking, methods for obtaining solutions for the shell differential equations [8] can be classified as follows: (i) Exact analytical methods, also known as classical solution; (ii) methods using variational calculus; (iii) numerical methods such as: finite difference, finite element, finite strip, to mention but a few; (iv) approximate methods based upon exact equilibrium of the problem.

Among others [1], [8], the classical solution, the finite difference, the finite element, the finite strip, the boundary element, the boundary collocation, and the boundary value methods are some of the well-known models used for solution of shell problems.

The classical solution gives accurate results but fails to capture the boundary conditions. The finite difference model considers the boundary conditions but does not give room to further optimization for the simple reason solutions are obtained only for some selected nodes. Finite element generates very large matrices for considerable accuracy, handling of those large matrices being only suitable for use of computer. Besides, they are numerical models. Numerical models are more inclined to approximate solutions than exact solutions. Those models connoting boundary in their names, sound though they may be, involve a level of mathematics beyond the scope of an average engineer!

The semi-moment theory is as suitable for circular cylindrical shells under hydrostatic pressure and uniform gas pressure as it is amenable to application of initial value model. This study adopts the initial value model for among the suggested analytical solutions. Initial value model gives the least number of unknowns enabling such manual handling as to imbue the analyst with the ability and privilege to solve a problem in so systemic a manner that represents a mandatorily profound understanding in the-every-step-of-the-way of the problem for the analyst.

III. Assumptions

a) Soil Characteristics

a. The filled earth outside the cylindrical shell structure is that of pure cohesionless soil.
b. The angle of internal friction, $\phi = 29^0$
c. $C = 0$
d. Unit weight of soil, $\gamma_s = 17.3 kN/m^3$
e. Condition of soil is dry.
f. The earth-filled top level is horizontal

b) The Cylindrical shell structure is fixed at its base or floor. It has a cover at the top. A cast insitu reinforced concrete slab serves as cover at the top, simply supported. The soil covers the walls of the tank from outside. The earth pressure is calculated without surcharge.

c) Parameters of the cylindrical shell structure

a. Height of tank = 4m
b. Radius of tank, R, = 5m
c. Thickness of tank, h = 0.2m
d. Unit weight of water, γ_w = 9.81 KN/m^3
e. Young's modulus of elasticity of concrete, Ec, 25 x 10^6 KN/m^2
f. Poisson's ratio, $\nu = 0.25$

d) When the tank is empty

i. Soil pressure at any level Z, is given by Ka γ_s Z
ii. When the tank is full:
iii. The net pressure on tank's wall becomes γ_w Z - Ka γ_s Z

Ring installation is neglected since the cylindrical shell reserviour is completely underground.

IV. Analysis

a) The Governing Equation of Equilibrium

[1] and [24] derived the governing differential equation of equilibrium as:

$$\frac{d^4W}{dx^4} + 4\beta^4 W = \frac{\gamma_x}{D} \quad \ldots\ldots\ldots\ldots (1)$$

Using, for the derivation, the following:

i. Forces acting on the shell;
ii. Moments acting on the shell;
iii. Equilibrium equations of stress;
iv. Equations of forces and moments displacements.

Equation (1) is applicable only to circular cylindrical shell structure subjected to axi-symmetric loading. This means the loading or forces and moments do not vary along the circumferential section. In other words, the loads are radially symmetrical loads.

For radially symmetrical loads, the governing differential equation of circular cylindrical shell structure, the equation of equilibrium, is equivalent to that of Beam on an elastic Winkler Foundation [34].

b) Initial Value Solution of The Governing Differential Equation of Equilibrium for Circular Cylindrical Shell Structure

i. *In Summary, initial value homogenous solution becomes:*

$$W_h(Z) = y_1(Z)W_0 + \frac{y_2(Z)}{\beta}\theta_0 - \frac{4\beta^2R^2}{Eh} y_3(Z)M_0 - \frac{4R^2}{Eh} y_4(Z)Q_0 \quad \ldots\ldots\ldots\ldots (2)$$

$$\theta_h(Z) = -4\beta\, y_4(Z)Wh + y_1(Z)\theta_0 - \frac{4\beta^3R^2}{Eh} y_4(Z)M_0 - \frac{4\beta^2R^2}{Eh} y_4(Z)Q_0 \quad \ldots\ldots\ldots\ldots (3)$$

$$M_h(Z) = \frac{Eh}{\beta^2R^2} y_3(Z)W_0 + \frac{Eh}{\beta^3R^3} Y_4(Z)\theta_0 + y_1(Z)M_0 + \frac{y_2Z}{\beta} Q_0 \quad \ldots\ldots\ldots\ldots (4)$$

$$Q_h(Z) = \frac{Eh}{\beta R^2} y_2(Z)W_0 + \frac{Eh}{\beta^2R^2} Y_3(Z)\theta_0 - 4\, y_4(Z)M_0 + y_1(Z)Q_0 \quad \ldots\ldots\ldots\ldots (5)$$

$$N_h(Z) = \left[\frac{Eh}{R} y_1(Z)\right]W_0 + \left[\frac{Eh}{\beta R} y_2(Z)\right]\theta_0 4\beta^2 Ry_3(Z)M_0 - 4\beta y_4(Z)Q_0 \quad \ldots\ldots\ldots\ldots (6)$$

ii. *The Initial Value Particular Solution Consider the following:*

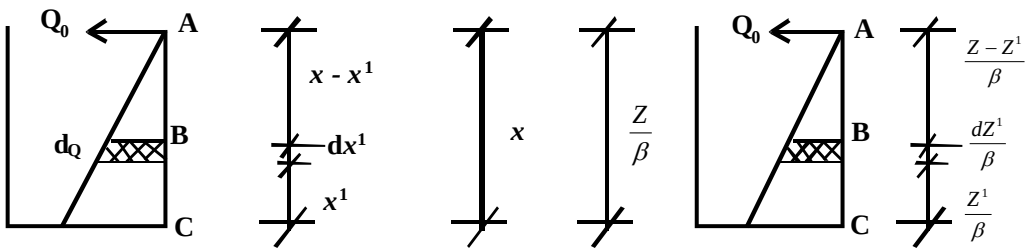

Fig. 1 : Origin Transformation

Understanding an origin transformation leads to finding the initial value particular solution. The origin that was previously at A is shifted to B, while introducing, at the same time, a new variable x^1.

$$\text{Let } Z^1 = \beta x^1 \Rightarrow dx^1 = \frac{dZ^1}{\beta}$$

He distributed load at the new origin, B, is given by:

$$q\left(Z^1\right)_w = \frac{Z - Z^1}{\beta}\gamma$$

∴ The elemental force can be expressed as:

$$dQ = q\left(Z^1\right)\frac{dZ^1}{\beta} = \frac{\gamma\left(Z - Z^1\right)}{\beta^2}dZ^1 \qquad \ldots\ldots\ldots\ldots (7)$$

In summary, the initial value particular solution would be:

$$W_p = \frac{\gamma R^2}{Eh\beta}\left[Z - y_2(Z)\right] \qquad \ldots\ldots\ldots\ldots\ldots (8)$$

$$\theta_p = \frac{R^2\gamma}{Eh}\left[1 - y_1(Z)\right] \qquad \ldots\ldots\ldots (9)$$

$$M_p = \frac{-\gamma}{\beta^3}y_4(Z) \qquad \ldots\ldots\ldots (10)$$

$$\theta_p \quad \frac{\gamma}{\beta^2}y_3(Z) \qquad \ldots\ldots\ldots\ldots\ldots (11)$$

$$N_p = \frac{\gamma R}{\beta}\left[Z - y_2(Z)\right] \qquad \ldots\ldots\ldots (12)$$

Obviously, general solution = homogeneous solution + particular solution.

c) Classical Model Homogeneous Solution

Basically, in summary, the homogenous solution would be as follows:

$$W_h(x) = c_1 e^{\beta x} * e^{i\beta x} + c_2 e^{\beta x} * e^{-\beta x} + c_3 e^{-i\beta x} * e^{-i\beta x} + c_4 e^{-\beta x} * e^{i\beta x} \qquad \ldots\ldots\ldots\ldots\ldots\ldots (13)$$

Where: C_1, C_2, C_3 and C_4 are constants.
Noting that:

$$e^{\beta x} = Cosh\beta x + Sin\beta x \qquad \ldots\ldots\ldots\ldots\ldots (14)$$

$$e^{-\beta x} = Cosh\beta x - Sinh\beta x \qquad \ldots\ldots\ldots\ldots\ldots (15)$$

$$e^{i\beta x} = Cos\beta x - iSin\beta x \qquad \ldots\ldots\ldots\ldots\ldots (16)$$

$$e^{-i\beta x} = Cos\beta x - iSin\beta x \qquad \ldots\ldots\ldots\ldots\ldots (17)$$

Equation [13] can be expressed as:

$$\begin{aligned} W_h(x) &= C_1\left(Cosh\beta x + Sinh\beta x\right)\left(Cos\beta x + iSin\beta x\right) \\ &+ C_2\left(Cosh\beta x + Sinh\beta x\right)\left(Cos\beta x - iSin\beta x\right) \\ &+ C_3\left(Cosh\beta x - Sinh\beta x\right)\left(Cos\beta x - iSin\beta x\right) \\ &+ C_4\left(Cosh\beta x - Sinh\beta x\right)\left(Cos\beta x + iSin\beta x\right) \end{aligned}$$

Expanding the above equation gives:

$$\begin{aligned} W_h(x) &= A_1 \quad Cosh\beta x Cos\beta x + A_2 Cosh\beta x Sin\beta x \\ &+ A_3 \quad Sinh\beta x Cos\beta x + A_4 Sinh\beta x Sin\beta x \qquad \ldots\ldots\ldots\ldots\ldots\ldots (18) \end{aligned}$$

Where:

$A_1 = C_1 + C_2 + C_3 + C_4$
$A_2 = (C_1 - C_2 - C_3 + C_4)\, i$

$A_3 = C_1 + C_2 - C_3 - C_4$
$A_4 = (C_1 - C_2 + C_3 - C_4)\, i$

d) Classical Model Particular Solution

Recall the static equation of equilibrium:

$$W^{IV} + 4\beta^4 W = \frac{\gamma}{D}x \qquad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (19)$$

Assuming the particular solution is of the form:

$$W_p(x) = ax \qquad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (20)$$

It follows that:

$$W_p^{IV}(x) = 0 \quad \text{.....(21)}$$

Making use of equations [20] and [21] in eqn [19] gives:

$$4\beta^4 ax + 4\beta^4 b = \frac{\gamma}{D}x \quad \text{..... (22)}$$

A comparison of co-efficient in equation [22] yields:

$$\left.\begin{aligned} b &= 0 \\ a &= \frac{\gamma}{4D\beta^4} \end{aligned}\right\} \quad \text{..... (23)}$$

Therefore, the classical model particular solution would be:

$$W_p(x) = \frac{\gamma}{4D\beta^4}x \quad \text{..... (24)}$$

Table 1: Summary of Internal Stresses When the Tank is Empty-Using the Initial Value Model

X(m)	Z	Deflection $W_{(z)}$(mm)	Slope $\Theta_{(z)}$ radians	Bending Moment $M_{(z)}$ (KNM)	Shear Force $Q_{(z)}$ (KN)	Hoop Tension $N_{(z)}$(KN)
0	0	0	0.000122536	0	0.743859755	0
0.8	1.036008026	0.000052788	0.000123922	-0.4857128716	-1.183174309	91.03938151
1.6	2.072016051	0.000165917	0.000129602	-1.516548554	-3.019258682	170.0885245
2.4	3.108024077	0.000473429	0.000145863	-4.247252695	-8.416752018	226.0594408
2.67	3.453360086	0.000670475	0.000156135	-5.962376315	-11.88682999	284.9352786
3.2	4.144032102	0.000134648	0.000190643	-11.73091094	-23.73505572	211.3360398
4.0	5.180040128	3.55×10^{-11}	-4.4×10^{-11}	-32.31896214	-67.01017443	2.7×10^{-7}

Table 2 : Summary of Values of Internal Stresses When the Tank is Empty – Using the Classical Model

X(m)	Z	Deflection W(Z)(mm)	Slope $\theta(Z)$ radians	Bending Moment M(Z) (KNM)	Shear Force Q(Z) (KN)	Hoop Tension N(Z)(KN)
0	0	0	0.000122486	0	-0.743859731	0
0.8	1.036008026	0.000052764	0.000123834	-0.4857128618	-1.183174342	91.03938184
1.6	2.072016051	0.000165855	0.000129585	-1.516548484	-3.019258654	170.0885258
2.4	3.108024077	0.000473396	0.000145792	-4.247252615	-8.416752001	226.0594463
2.67	3.453360086	0.000670493	0.000156193	-5.962376293	-11.88682675	284.9352765
3.2	4.144032102	0.00134592	0.000190589	-11.73091124	-23.73505498	211.33360358
4.0	5.180040128	4.27×10^{-12}	3.84×10^{-13}	-32.31896187	-67.01017413	2.3×10^{-8}

Table 3 : Summary of Values of Internal Stresses When the Tank is Full – Using the Initial Value Model

X(m)	Z	Deflection W(Z)(m)	Slope $\theta(Z)$ (radians)	Bending Moment M(Z) (KNM)	Shear Force Q(Z) (KN)	Hoop Tension N(Z)(KN)
0	0	0	0.000077722	0	-0.471813873	0
0.8	1.036008026	0.000033482	0.000078601	-0.3085154309	-0.750461426	57.7444589
1.6	2.072016051	0.000105238	0.000082204	-0.9619133775	-1.915049339	107.8828632
2.4	3.108024077	0.000300286	0.000092518	-2.693938928	-5.338560581	143.3830003
2.67	3.453360086	0.000425269	0.000099033	-3.781804103	-7.539554672	180.7287485
3.2	4.144032102	0.000854047	0.000012092	-7.44065868	-15.05462351	134.0462233
4.0	5.180040128	-2.53×10^{-11}	-3.4×10^{-11}	-20.49920654	-42.50307896	-1.14×10^{-7}

Table 4 : Summary of Values of Internal Stresses when the Tank is Full – using the Classical Model

X(m)	Z	Deflection W(Z)(m)	Slope $\theta(Z)$ (radians)	Bending Moment M(Z) (KNM)	Shear Force Q(Z) (KN)	Hoop Tension N(Z)(KN)
0	0	0	0.000177694	0	-0.471813792	0
0.8	1.036008026	0.000033471	0.000078595	-0.3085154293	-0.750461386	57.7444536
1.6	2.072016051	0.000105168	0.000082193	-0.9619133724	-1.915049295	107.8828584
2.4	3.108024077	0.000300245	0.000092512	-2.693938892	-5.338560528	143.3830001
2.67	3.453360086	0.000425218	0.000099021	-3.781804084	-7.539554622	180.7287423
3.2	4.144032102	0.000854014	0.000012024	-7.44065818	-15.05462316	134.0462194
4.0	5.180040128	-3.62×10^{-12}	2.94×10^{-13}	-20.49920612	-42.50307854	1.21×10^{-8}

Table 5 : Summary of Values of Percentage Difference for Internal Stresses: When the Tank is Empty Versus When the Tank is Full

X(m)	Z	Deflection $\%\Delta$	Rotation $\%\Delta$	Bending Moment $\%\Delta$	Shear Force $\%\Delta$	Hoop Tension $\%\Delta$
0	0	0	36.572	0	36.572	0
0.8	1.036008026	36.572	36.572	36.572	36.572	34.572
1.6	2.072016051	36.572	36.572	36.572	36.572	36.572
2.4	3.108024077	36.572	36.572	36.572	36.572	36.572
2.67	3.453360086	36.572	36.572	36.572	36.572	36.572
3.2	4.144032102	36.572	36.572	36.572	36.572	36.572
4.0	5.180040128	0	0	36.572	36.572	0
TOTAL		182.86	219.432	219.432	256.004	182.86
Average Value		36.572	36.572	36.572	36.572	36.572
Total Average =		182.86				
Overall Average =		36.572				

* Percentage difference, $\%\Delta$, for applied pressure on tank wall: when the tank is empty versus when the tank is Full, = 36.572.

* Overall average percentage difference, $\%\Delta$, value for results of internal stresses for: when the tank is empty versus when the tank is full = 36.572

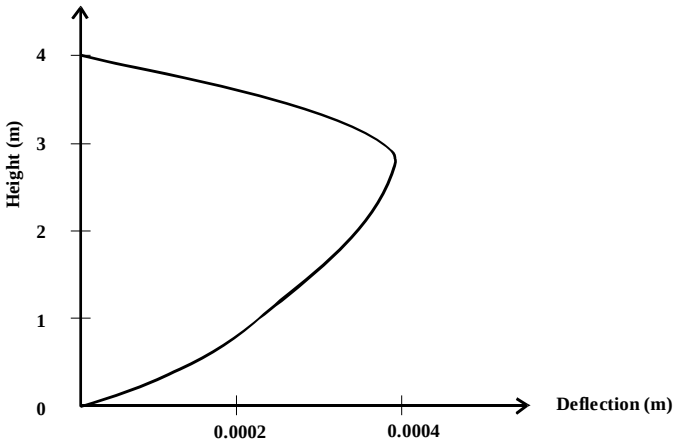

Fig. 2 : Deflection Diagram

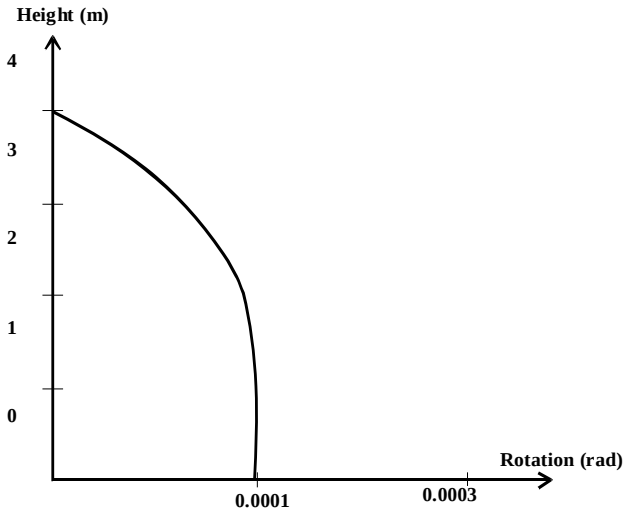

Fig. 3 : Rotation (Slope) Diagram

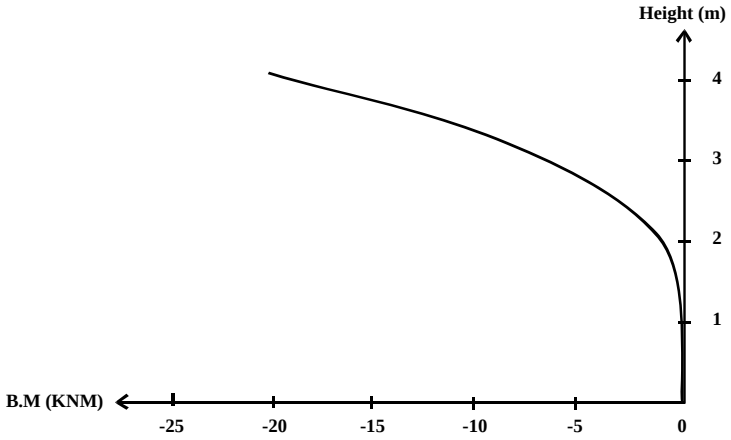

Fig. 4 : Bending Moment Diagram

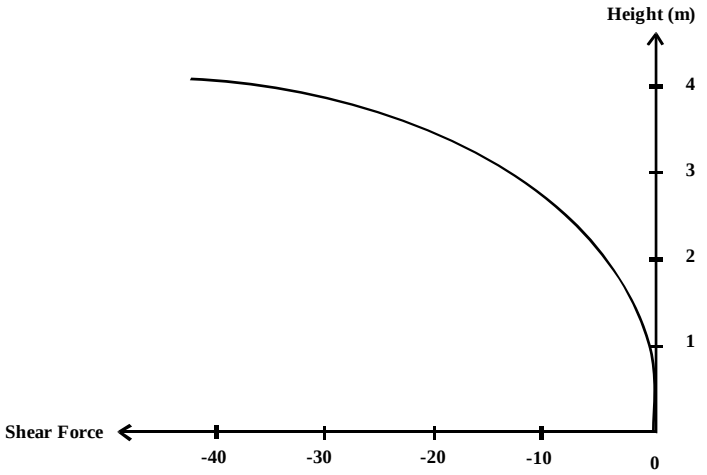

Fig. 5 : Shear Force Diagram

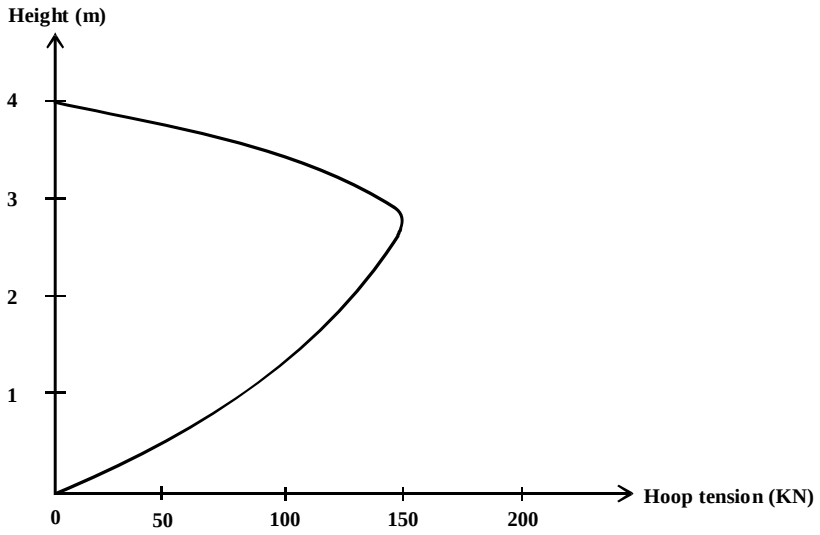

Fig. 6 : Hoop Tension Diagram

V. Discussion of Results

a) Solution of the Governing Differential Equation of Equilibrium

Two approaches were used in the analysis: the classical and initial value models. Two totally different approaches though they are, they led to identical results.

b) Internal Stresses

i. *Direct Deflection*

The deflection curve, for the hydrostatic loading, fig. 2, has a parabolic like shape with a speak of 0.854 mm at x = 3.2m from the top. Zero deflection is obtained at both top and bottom ends of the reservoir, justifying zero deflection at the supports. Also, tables 3 and 4 refer.

ii. *Rotation*

Under hydrostatic pressure, fig. 2, tables 3 and 4, the reservoir presented a maximum rotation of 0.078 x 10^{-3} radians at its top end.

iii. *Bending Moment*

For the hydrostatic loading, fig. 3, tables 3 and 4, the bending moment varies from zero, at the top, to 20.5KMN at the bottom, describing a concave parabolic-like curve due to the cantilever action.

iv. *Shear Force*

In the case of hydrostatic loading, the shearing force varies from 0.472KN, at the top, through 42.503KN, at the bottom, fig. 5, tables 3 and 4.

v. *Hoop Tension*

The graphs, fig. 6, have the same shape as those obtained for direct deflection. For real, deflection and hoop tension are directly proportional. For the hydrostatic pressure, a peak of 180.729 KN is reached at x = 2.67m, fig. 6, tables 3 and 4.

The tables 3 and 4 show values for deflection and rotation at the bottom, x = 4m, not exactly equal to zero, but very close to zero in the extent they can be taken as zero with sufficient accuracy.

vi. *Stress effect at: when empty versus when full of water*

Table 5 reveals: (i) percentage difference for applied pressure on tank wall, when the tank is empty versus when the tank is full of water, is equal to: 36.572; (ii) Overall average percentage difference value for results of internal stresses for, when the tank is empty versus when the tank is full of water, is equal to: 36.572.

c) Conclusion and Recommendation

i. *Conclusion*

The half-moment theory, otherwise known as semi-moment theory appears to have proven to be one of the most accurate theories in shell analysis. It has the advantage to be more realistic than the membrane theory which does not consider the bending effect. The semi-moment theory is simpler than the moment theory which generates heavy equations.

In terms of capturing the boundary conditions of systems, the initial value model is more equipped than the classical model.

Sequel to results revealing that: percentage difference for applied pressure on tank wall: when the tank is empty versus when the tank is full of water is equal to 36.572%; again the overall average percentage difference value for results of internal stresses with respect to: when the tank is empty versus when the tank is full of water came to 36.572% as well, stress effect on the water reservoir which resulted from the two conditions would not diminish the fundamental structural integrity of the underground circular cylindrical shell structure, if all other sources of stress such as from weather elements are under control.

ii. *Recommendation*

i) The shell analyst could well feel free to adopt either the initial value model or the classical model for analysis. ii) Structural analysis of cylindrical shells and other types of shells should attract more interests of structural analysts. Further studies could be undertaken in: i) The furtherance of efforts towards making the analysis of shells simpler than this has ever been. ii) Study of stress effects on this facility with respect to other stress sources such as weather elements.

Notation

$$y_1(Z) = \Psi(Z) = CoshZ\ CosZ$$

$$y_2(Z) = \frac{1}{2}\left[\Psi_2(Z) + \Psi_3(Z)\right] = \frac{1}{2}\left[CoshZ\ SinZ + SinhZ\ CosZ\right]$$

$$y_3(Z) = \frac{1}{2}\Psi_4(Z) = \frac{1}{2}\left(SinhZ\ SinZ\right)$$

$$y_4(Z) = \frac{1}{4}\left[\Psi_2(Z) - \Psi_3(Z)\right] = \frac{1}{4}\left[CoshZ\ SinZ - SinhZ\ CosZ\right]$$

$$\beta^4 = \frac{3(1-V^2)}{R^2h^2}$$

L = Overall height of Reservoir

Ka = $\frac{1 - \sin\phi}{1 + \sin\phi}$ or $\mathrm{Tan}^2(45 - \frac{\phi}{2})$

Φ = Angle of internal friction of soil.

Z = βL

D = Flexural Rigidity of shell element.

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Global Journal of Researches in Engineering: E
Civil And Structural Engineering
Volume 16 Issue 3 Version 1.0 Year 2016
Type: Double Blind Peer Reviewed International Research Journal
Publisher: Global Journals Inc. (USA)
Online ISSN: 2249-4596 & Print ISSN: 0975-5861

Column-Base Plate Connection under Monotonic Load: Experimental and theoretical Analysis

By Seyed Mostafa Shabanian, Gholamreza Abdollahzadeh & Amir sina Tavakol

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Abstract- Connections in steel structures have an important impact on the behavior of the entire structure. One of them existed in the connection of column to base plate. The appropriate understanding of structural connections behavior and the awareness of how transmission of power occurred by their connections and more accurate understanding of their behavior is essential for modeling and structural analysis. In the following study, at first, the connection of the column to base palte was studied under the monotonic loading in laboratory. Then, the finite element method and criteria are used for designing the moment-rotation curve. The results of the study indicated that the moment-rotation curve of in experimental sample and the analytical methods are reasonably close to each other. Therefore, the finite element methods and criteria can be used with reasonable accuracy in the behavior evaluation of this type of connection.

Keywords: *column to base plate connection, moment-rotation curve, rigidity.*

GJRE-E Classification : *FOR Code: 290899*

Strictly as per the compliance and regulations of :

Column-Base Plate Connection under Monotonic Load: Experimental and theoretical Analysis

Seyed Mostafa Shabanian [α], Gholamreza Abdollahzadeh [σ] & Amir sina Tavakol [ρ]

Abstract- Connections in steel structures have an important impact on the behavior of the entire structure. One of them existed in the connection of column to base plate. The appropriate understanding of structural connections behavior and the awareness of how transmission of power occurred by their connections and more accurate understanding of their behavior is essential for modeling and structural analysis. In the following study, at first, the connection of the column to base palte was studied under the monotonic loading in laboratory. Then, the finite element method and criteria are used for designing the moment-rotation curve. The results of the study indicated that the moment-rotation curve of in experimental sample and the analytical methods are reasonably close to each other. Therefore, the finite element methods and criteria can be used with reasonable accuracy in the behavior evaluation of this type of connection.

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I. Introduction

One of the most important steel structure connections in this study is the connection of column to base plate because it transfers all the forces of entire structure to the foundation and it is themaximum point of axial and shear forces and some moment-rotation curves. This connection is the place of overall instability and destruction of structure specifically at the time of earthquake and it effects on the behavior of entire structure. Therefore, careful consideration of its behavior especially its seismic behavior is very important. It has been observed in some cases that the lack of proper application of design or construction caused in the destruction of structure. One particular issue which increases the importance of column base connection evaluation is the effect of various members and their features in connection. These connections are consisted of columns, plates of base plates, foundations and bolts. [1-6] This connection behavior is influenced by different parameters. The most important of these parameters can be assessed as follows:

- Dimensions and thickness of columns base
- Diameter, length and position of tie rods
- Strength of available materials included sheets, tie rods and concrete
- Geometry in the foundation
- The type of loading
- The distance between the edge of columns and base plate
- The ratio of concrete surface to sheet surface

The Classification of this connection can be done in different ways. This classification can be classified as behavioral perspective, resistance, energy dissipation capacity, failure mode and the ways of loading. Several methods and experiments by different researchers in different fields have been done for the behavior of columns base, different components and factors affecting the connection. Most of these studies have been carried for the behavior of connection in the static loading or numerical study of the connection behavior.[7-12] Today, good methods for assessing resistance and initial stiffness have been developed. But for other features such as rotational capacity, curve, there is no appropriate way to the appropriate level. If these features could be estimated accurately, significant progress had been achieved in structural design. In this study, for estimating the columns to base plate connection response, independent of the experiment results, the component-based modeling and finite element method were used. First, component-based modeling in compliance with the mechanical principles was introduced and then the moment-rotational curve has obtained. Then the sample was modeled by ANSYS finite element software and loaded by monotonic loading. The prepared samples in the laboratory of Babol Noshirvani University of Technology have been loaded under monotonic loading and the results were recorded. The results of laboratory tests have been used as a verification model. In the end, the advantages and disadvantages of two models in comparison to laboratory models were discussed.

II. Laboratory Evaluation

The main and common methods for determining the curve is experiment on the connections. For designing curves, bending moments were directly measured by the static loading of experimental sample and rotational angles based on the transferring of beams in comparison to depth. For this purpose, a scale model for carrying this study was built at the

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laboratory of Babol Noshrivani University of Technology. For creating the samples, firstly, the required sample sections were prepared and drilled. In addition, the final assembly was carried out in the laboratory. Due to the uncertainty of welding in the laboratory, the required welding was carried in the factory. To investigate the behavior of real-time connection load, a node was entered to the connection increasingly. On the other words, at each stage of loading, the load on the connection was increased about certain weight which is more than before the last one. This loading continues until the connection is destroyed. The type of materials and the geometry characteristics of connection is provided in Table 1.Concrete with resistance of 282 kilograms per square centimeter was used for concrete Pedestal and tie rods was M20.

Table 1: Geometry characteristics and consumable materials

Tie rod	Plate thickness (cm)	plate dimention (cm)	The column section	Concrete foundation dimensions (cm)
$M20$	20	50×50	$HEA-200$	50×60

Samples were design according to $Eurocode3$ for this state that buckling plate and tie rode occur simultaneously. The purpose of this design is that the plastic deformation can be seen in the plate and the bolts. Column size and the ratio of width to thickness was selected in such a way that the column buckling does not occur before plate rupture. The figure 1 shows the laboratory sample of column connection to base plate and loading device.

Figure 1 : The experimental model of the column to base plate joint

Figure 2 : The loading device (model Enerpac-ZE5)

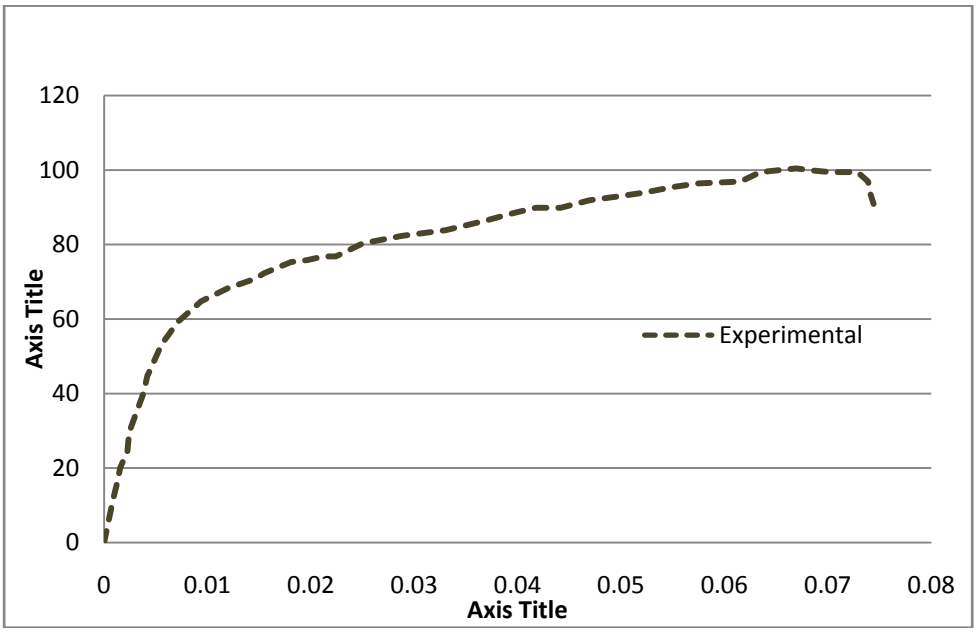

Figure 3 : Moment-rotation curve for experimental sample

III. Component-Based Model

In the component-based modeling, at first the component connection are separated to its structural connection and the stiffness of each component was obtained. The entire stiffness was obtained through the sum of each stiffness component and their parameters were introduced by a suitable mathematical relationship. The diagram of moment-rotation curve was achieved. The mathematical model parameters must be defined in such a way that they can calculated using the material properties and geometry dimensions. The application of component base modeling was associated with the four basic steps.[13-17]

- Identifying the components connection
- Characterization of each component
- The combination of elements for assessing the general behavior of connection
- Classification and Modeling

The main idea of this method is based on the study of zoetemeijer in 1983. In order to identify the behavior of components, they are often loaded by tensile, pressure and shear loading. The accuracy of this method depends on the accuracy of their characteristics and the method of components combination. In this method, it is assumed that component properties are completely independent of each other and therefore these characteristics can be easily achieved. The components behavior can be stated with a non-linear relationship of force-displacement. The components behavior is generally non-linear behavior, but it can be as simple as the two or three linear models. The model parameters can be obtained from the dimensions of the components and materials properties. The most important parameters in the mathematical model are design resistance, stiffness factor and deformation capacity. Understanding the factors of connection and failure associated modes is the first phase of the component method modeling. Rotation described the connection with the deformation of four sources which two of the sources located in stretching zone and two other sources placed in compression zone. It includes concrete under pressure with grout, and flange columns in the press, the plate of column base under bending and bolts under tensile.[18,19]

In sum, the components of column to base plate connection are as follow:

- The pressure part (concrete under pressure and column base under bending)
- The Column
- The Tensional part (including tie rods and sheet under bending)
- The transfer part of cutting force

The idea of evaluating the resistance and stiffness of base plate has been expressed by Jas part and Melchers. The regulations of Euro code 3 used this method to determine the characteristics of the components for the two connections to column and column to base plate. In the plate components, three different failures have been investigated.

- Rupture of tie rod as the result of the top plate
- Start creating lines in the sheet before achieving to the point of tie rod resistance
- Failure of a compound that includes the creation of complete lines, but without creating mechanisms plastic plate does not happen.

In order to design the rotation-moment curve which is indicated the entire node behavior, the characteristics of each component must be combined properly. To this end, appropriate mechanical and analytical models should be developed. Mechanical model provided by Jas part et al is presented in figure 4 and it is based on simulations of two-dimensional nonlinear springs. This model not only considered the nonlinear behavior of each component, but also takes the impact of the changes affecting the bending area. The model is very complicated for engineering and design applications. The applied component model in necessary to determine the design strength, stiffness and deformation capacity of this type of connection. [20,21]

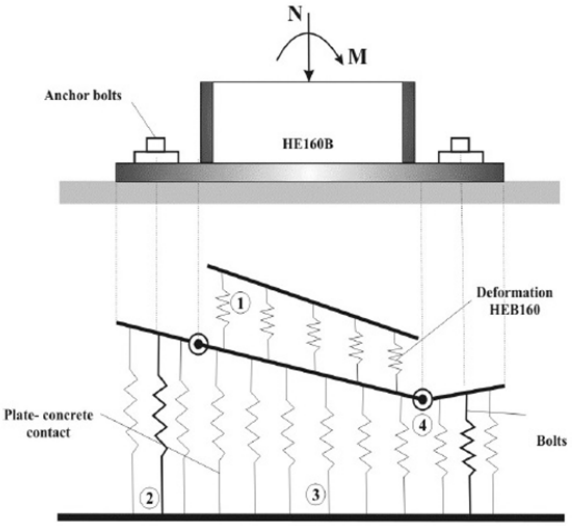

Figure 4 : The mechanical model of column to base plate connection

It can be understood from presented models that the choice of effective area is very essential in the complexity of the final model. The reason for this is that in the process of combining components, the influence of vertical force and bending moment must be considered. The actual values of these forces are effective in the position of the neutral fiber that this case is linked to the effective area. Most suggestions for effective area is presented based on the regulation of Euro code 3. In this regulation, the stress distribution on concrete is assumed under the plate of column base. To calculate the resistance, the easiest method is the perfect plastic stress distribution. Rotational stiffness is achieved based on the model provided in the Eurocode 3.[22,23]

IV. Finite Element Model

Finite element method which is a subset of numerical methods is one of the most practical methods for solving the engineering problems. In 1960, the so-called finite element was firstly used by Clough to solve the problems of two-dimensional elasticity. In the finite element method, the physical issues were solved with the help of differential equations and minimizing the potential energy. By this assumption that the number of degrees of freedom is reduced a limited from the infinite degrees of freedom. In the finite element method the available continuous environment is divided into a finite number of smaller components with simple geometry and then for components of a displacement function which link the displacement of each point to shift nodes. It is assumed that due to the complex geometry of column base connections, and multi-phase environment of connections in terms of material type, in finite element models, the number of degrees of freedom is very high and relevant volume calculation is more than usual for conventional computers. The other reason which leads to the complexity is the multiplicity types of nonlinear behavior in these models. This cause that the solution engine repeatedly increase the frequency of each incremental step. In addition, in the original version, the existence of periodic load increases the influence of this issue. Therefore, it is inevitable to consider simplification for modeling. [24-28]

In the present study, the finite element software (ANSYS) is used for modeling the column to base plate connections. SOLID components have been used to establish components connections. Contact surface friction coefficient of 0.6 is assumed to consider the frictional forces. To model the effect of pre stressing screw in modeling, PRETS179 has been used. The holes of screws were modeled 2 mm larger than the diameter of the screws. In all models by dividing the geometry of the steel mesh into the separate parts, an attempt has been made to achieve the best split lattice. The parameters used to define the size of the mesh elements were the length of elemt in near areas (l_e), the length of element in remote areas (l'_e), the number of

elements in thickness of column base plate(n_e), and the number of elements in column flange thickness (n'_e).

Table 2 : Naming of meshing in finite element model

The number of nodes	The number of elements	l'_e	n'_e	l_e	n_e	Naming Mesh
20175	13644	14	3	6.5	4	small

Areas near the connection have been modeled with the finer elements. These areas included bolts, column base plate, and end parts of the column to a distance twice the depth of the column plate which can be seen in Figure 5.

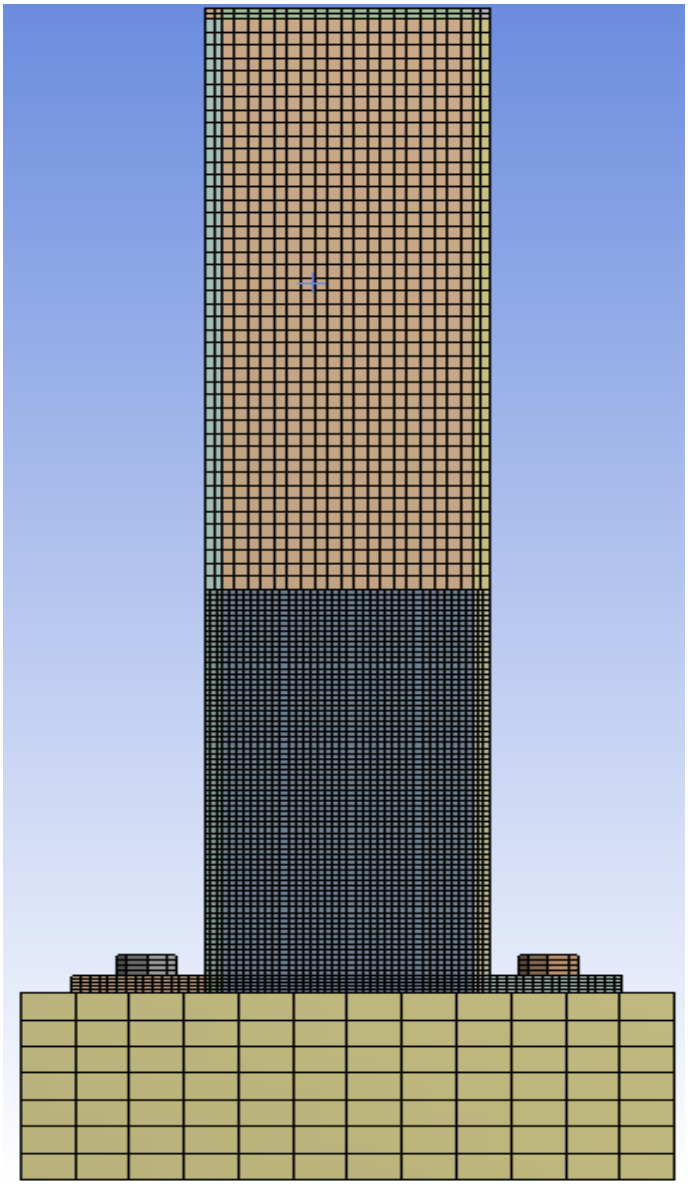

Figure 5 : Meshing of column components connection to the column base

Depending on the type of loading that has been done, the type of material used in hardening steel is considered isotropic which is listed in Table 3. Drucker-Prageralso used to modify the concrete behavior. This material is providing the possibility of penetrating elements of column base plate to the size of about 0.5 cm in the concrete.

Table 3 : Basic characteristics of materials dedicated to components connection

Yield stress	Modulus of elasticity	The abbreviated name	Corresponding part
235 *Mpa*	2.1×10^5 *Mpa*	S235	column base plate
355 *Mpa*	2.1×10^5 *Mpa*	S355	columns
900 *Mpa*	2.1×10^5 *Mpa*	Grade10.8	bolts
25 *Mpa*	2.5×10^4 *Mpa*	C25	Pedestal

V. The Evaluation of Results

Evaluation of results based on component-based modeling. In the component-based method, modeling for a macro elements is provided by the combination of rigid rods and springs which represents the constructive engagement of the component. In this way, each of the deformation mechanisms and rigidity in specific connection is determined by testing them individually or referring to regulations. The rigidity of each components is modeled by the linear or nonlinear spring and the sum of these springs in series or parallel connections can be assembled to determine rigidity. Component-based method uses the combination of rigid elements and deformable (spring) which can indicate the source of deformation of a single component. Components usually have been modeled mechanically by the geometric properties of substances and materials. The performance of mechanical models gives a satisfactory prediction of the curve. Figure 6 shows a comparison between experimental results and the component-based model.

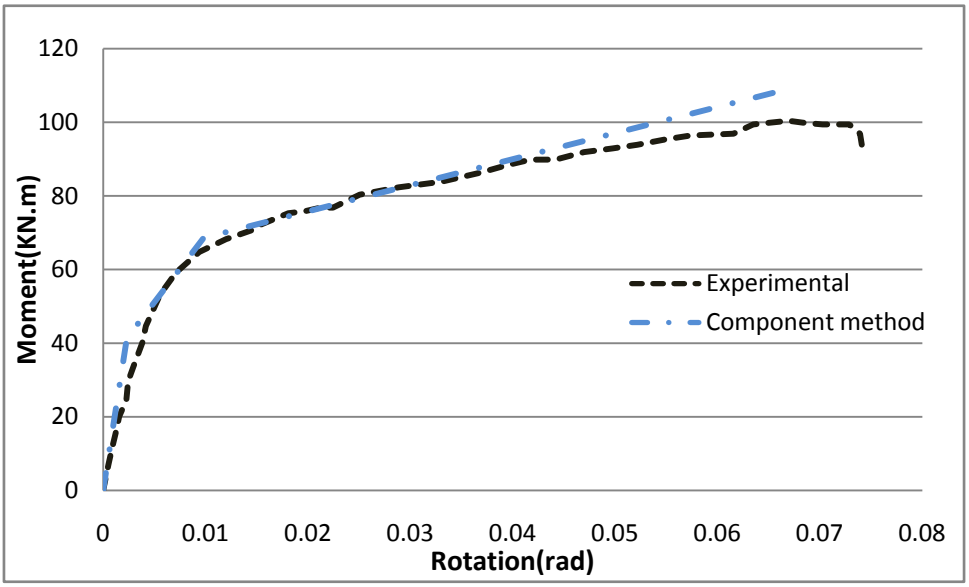

Figure 6 : The Comparison between moment- rotational curve for experimental sample based on component model

The differences are due to the defects, mismatch and residual stress of the experimental setup which cannot be easily considered in computational models. The impact of these factors can be very high in the initial stiffness.

a) The results evaluation of finite element modeling

In the present study, the performance of finite element method of column connections to the based columns has been compared with the experimental results. In general, the finite element models can appear in the prediction of reliable curves. They can effectively estimate the initial stiffness and connections resistance. If all nonlinear properties of all connected materials are taken into account, it can estimate the rotational capacity of connections. This type of loading analysis is non-linear statistic model. Non-linear analysis is included the analysis of nonlinear material, geometric non-linear and nonlinear contact. In the process of the finite element model loading, load point is applied to the end of the column in the incremental linear to the finite element model. Figure 7 shows a comparison between the experimental results and finite element model.

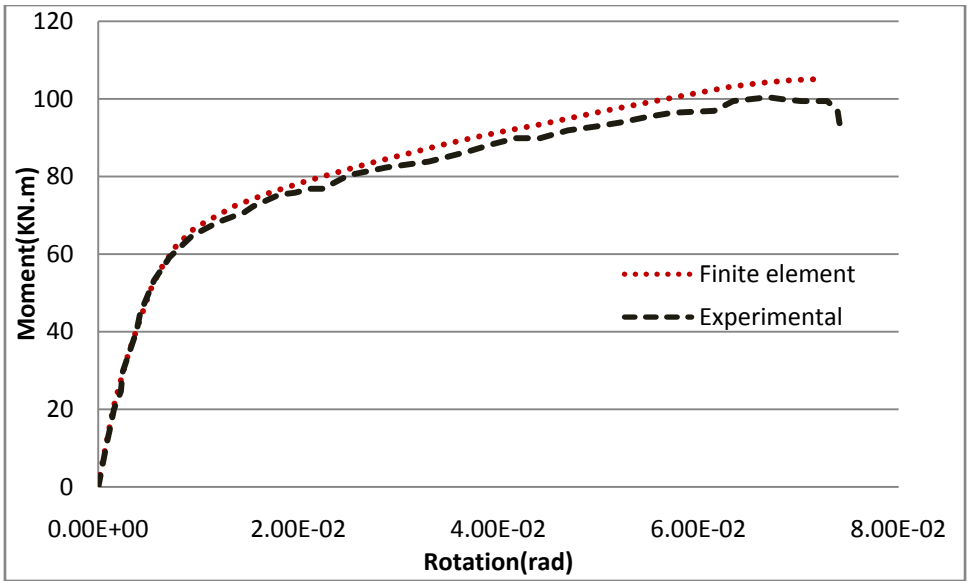

Figure 7 : The comparison of moment-rotational curve for laboratory samples and finite element

It can be seen that the stiffness of model in the initial slope of the component model is a little more than experimental model. One reason for this could be the shorter length of bolts in the numerical model which leads to the hardness of primary connection. In contrast with the increasing of load amounts, the behavior of other components will have a greater role in nonlinear connection response.

VI. Conclusion

In this study the behavioral curve of column connection to its based were examined through the modeling of finite element and component-based and the results of these methods were compared with the results from the laboratory. The results are presented in the following paragraph:

- By comparing the results obtained from finite element method and the results of laboratory tests it was found that in the linear region, the results are entirely consistent. But by entering to the nonlinear region, the curves are to some extent far from each other. The reasons for this difference can be the different experimental conditions in comparison to the analytical model, equipment errors used for loading, recording the results, boundary conditions, the difference in real terms other materials beam and column, and different behavior of welding elements in real models and analytical models.
- The comparison of the results indicated that there is acceptable agreement between the moment rotational curve obtained from components and laboratory tests. The differences between these two moment-rotation curves are based on some factors such as the sliding of screw and elliptical mode of the screw holes. Thus it can be concluded that the component method for parameterization the behavior of this type of connection has acceptable accuracy. In addition, by this method the number of trials and errors that have a lot of cost can be reduced.

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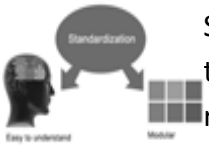

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Before start writing a good quality Computer Science Research Paper, let us first understand what is Computer Science Research Paper? So, Computer Science Research Paper is the paper which is written by professionals or scientists who are associated 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.

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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.

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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.

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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.

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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.

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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.

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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

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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.

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- 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:

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- 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.

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- Shape the theory/purpose specifically - do not take a broad view.
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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.
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- 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

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- 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

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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."
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- 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
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- Submit to generally acknowledged facts and main beliefs in present tense.

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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

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ISSN 9755861