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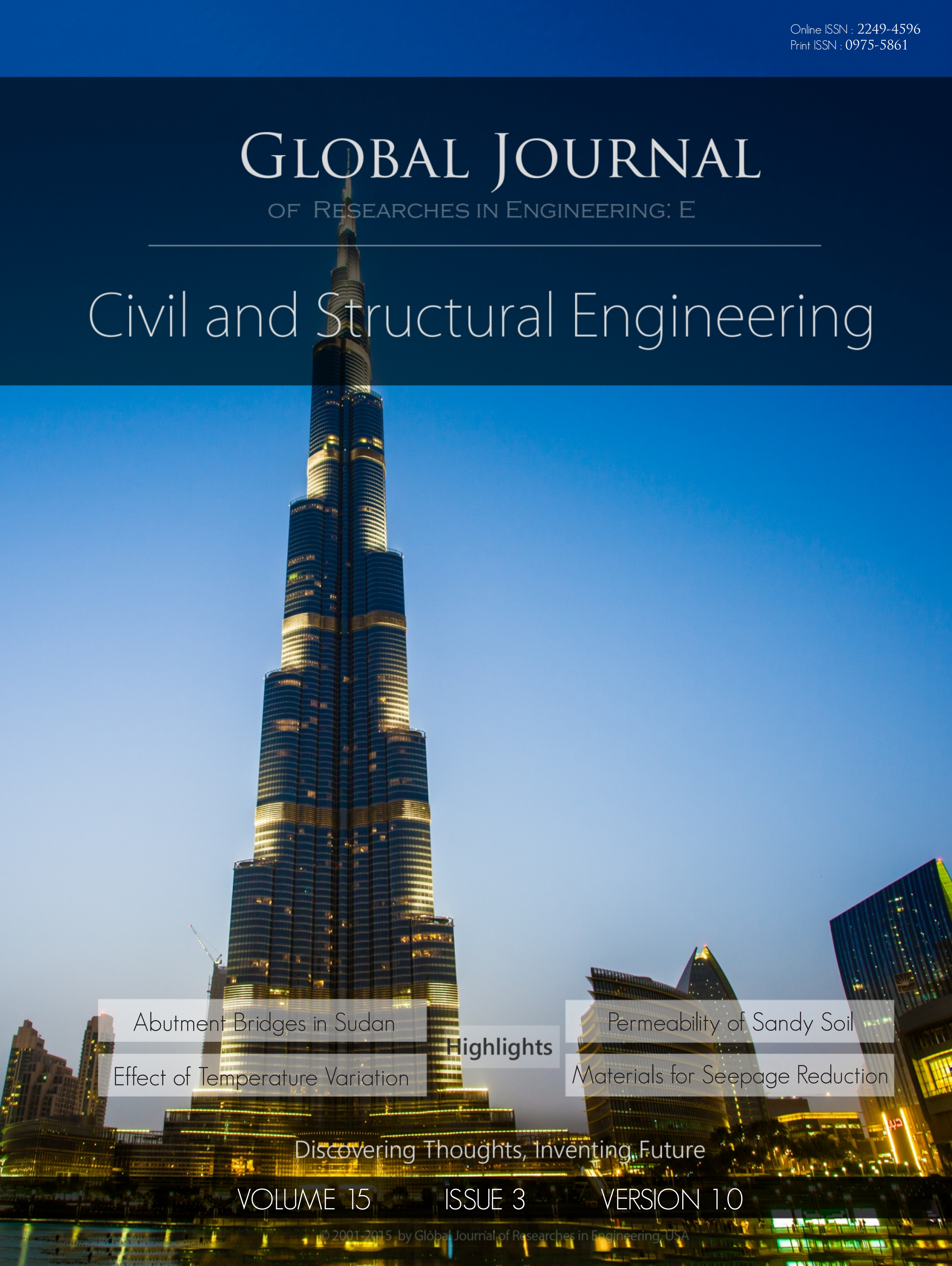

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Effect of Temperature Variation

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Materials for Seepage Reduction

Discovering Thoughts, Inventing Future

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Performance based Design of Wharves with Steel Pipe Pile

By Vitaly B. Feygin

Introdution- This paper reviews Performance Based approach (also called Direct Displacement Design method) pier structures, and is built as an extension of the standards developed by POLA/POLB1.

The paper reviews performance design of the pier structures supported on steel pipe piles with steel pipe “shear plug” connectors, and benefits of steel pipe sections for design of piers in regions with a moderate to high seismic activity.

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PERFORMANCEBASEDDESIGNOFWHARVESWITHSTEELPIPEPILE

Strictly as per the compliance and regulations of :

Performance based Design of Wharves with Steel Pipe Piles

Vitaly B. Feygin P. E.

I. Introduction

This paper reviews Performance Based approach (also called Direct Displacement Design method) pier structures, and is built as an extension of the standards developed by POLA/POLB[1].

The paper reviews performance design of the pier structures supported on steel pipe piles with steel pipe "shear plug" connectors, and benefits of steel pipe sections for design of piers in regions with a moderate to high seismic activity.

II. Performance-based Seismic Design Approach

The following is a review of two most reputable sources on the seismic event criteria utilized by a Direct Displacement Method:

- *PIANC WG-34.*

PIANC reviews only two levels of seismic event:

<u>L1 event</u> – 72 year RP

<u>L2 event</u> – 475 year RP

- *POLA/POLB 2012:*

The current Port of Long Beach Wharf Design Criteria identifies three seismic events using Poisson equation:

L1 event – 72 year RP or 50% probability of exceedance in 50 years. (Operating Level Earthquake)

$0.5 = 1- (1- P)^{50}$ or rewriting expression as a Log function

$Log\ (1\text{-}P)^{0.5} = 50 = Log_{10}\ 0.5\ /\ Log_{10}\ (1\text{-}P) \ ==>$ $P=0.0137,\ T=1/P = 72$ *years*

L2 event – 475 year RP or 10% probability of being exceeded in 50 years. (Contingency Level or Design Basis Earthquake)

$0.1 = 1- (1- P)^{50}$

$Log\ (1- P)^{0.9} = 50 = Log_{10}\ 0.9\ /\ Log_{10}\ (1\text{-}P) \ ==>$ $P=0.0021,\ T=1/P = 475$ *years*

L3 event – 2475 year RP (Code Level Design Eartquake or MCE)

$0.02 = 1- (1- P)^{50}$

$Log\ (1- P)^{0.98} = 50 = Log_{10}\ 0.98\ /\ Log_{10}\ (1\text{-}P) \ ==>$ $P=0.000404,\ T=1/P = 2475$ *years*

Where,

P – annual exceedance probability

T- mean recurrence interval

In a Force Based design method, Design Level Earthquake is determined by scaling mapped M(aximum)C(onsidered)E(arthquake) by a factor of 2/3. In a stark contrast, Displacement Design Method places emphasis on the performance of the structure at different levels of seismic events, rather than on required structural strength corresponding to a single fictitious force of the Design Level Earthquake.

Unlike Force Based design approach based on a single 475 year R(eturn)P(eriod) seismic event, Displacement Design Method reviews structural performance at forces corresponding to 3 distinguished seismic cases:

Level L1 (72 year RP case) – Operating level event. Structure should not experience any distress.

L2 (475 year RP case) – Design level event. Structure shall stay in service and / or be economically repairable within a month.

L3 (2475 year RP case) – Extreme level event. The structure should not collapse during or after seismic event. However, structure might be unsalvageable.

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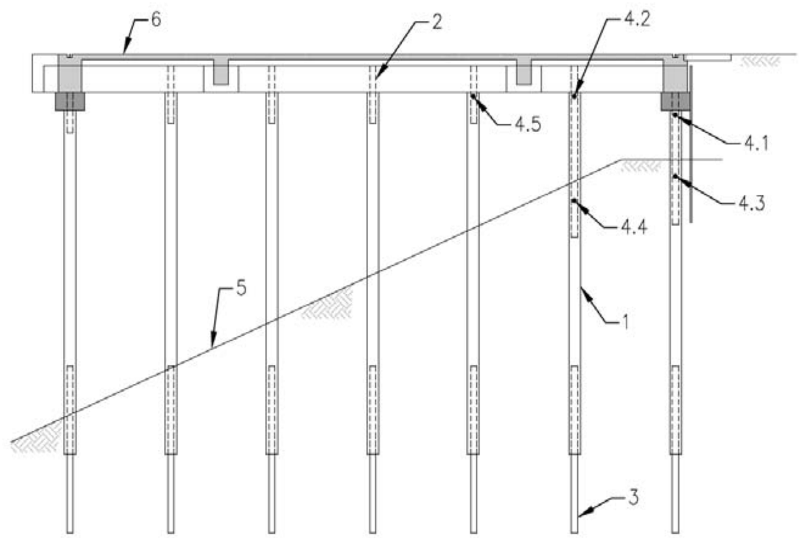


1. STARTING PILE
2. SHEAR PLUG INSERT
3. TELESCOPIC PILE
4.X POTENTIAL PLASTIC HINGES 1,2,3,4
5. DIKE
6. DECK CONSTRUCTION

FIG. 1a

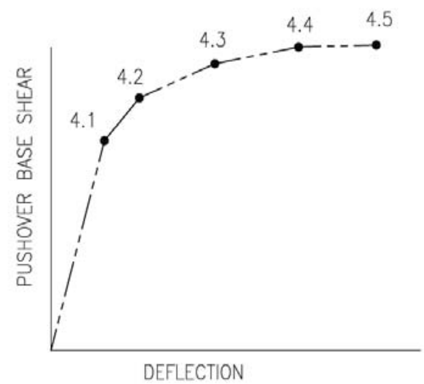


FIG. 1b

DEVELOPMENT OF PLASTIC HINGES

Performance of the pier structure is described by the pier bent diagram shown in *Figures 1a* and graph indicating sequence of plastic hinge development *Figure 1b*

For proper results, pushover analysis model required for Direct Displacement Design should utilize only Effective Section Properties of the pile section.

The performance analysis of arbitrary concrete section presented by POLA, and deficiency of such analysis is explained below:

The well known relationship between the curvature and flexural moment in terms of Effective Section Moment of inertia for concrete section provides a true statement only for slowly propagating cracks typical for static load application.

$$I_{eff} = M_y / (\kappa_y * E_{ce}) \qquad \textit{(Formula 1)}$$

Where,

M_y – Moment capacity of the section at first yield point.

$\kappa_y = \varepsilon_y / c_y$ – curvature at a point where the first rebar or dowel in the concrete section yields

ε_y – strain in concrete at first yield point.

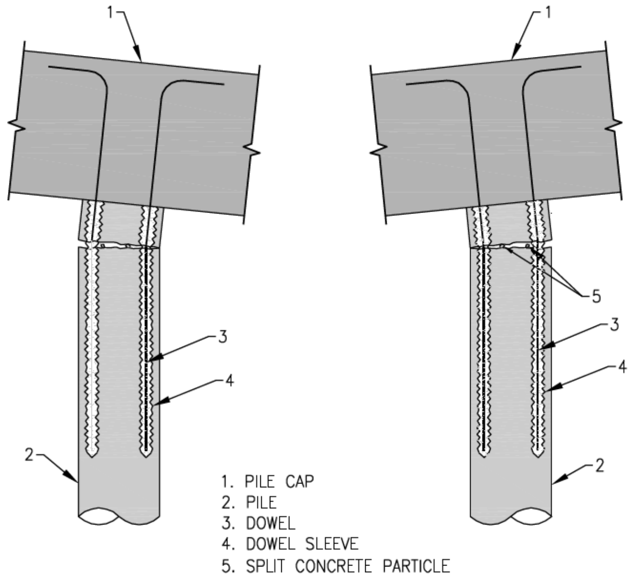
c_y – distance from the extreme compression fiber to the Neutral Axis

E_{ce} – expected compressive strength of concrete

The crack propagation during the sign changing dynamic load application is different.

Fast propagating cracks caused by sign changing dynamic force cannot be described by the position of the Neutral Axis.

Development of such crack depends on the location of the floating fulcrum point shown by position 5 in *Figure 1c*.



PLASTIC HINGE DEVELOPMENT
POLA / POLB CONNECTION DETAIL
FIG. 1c

The width of the crack in the concrete section grows with each cycle, displacing and moving fulcrum points formed by the split particles of the concrete jammed between the two plans of the crack.

It should be noted that prestressed strands at the pile top are not developed (strands were not shown in Fig.1c for clarity), and flexural capacity of the pile at the pile to pile cap interface depends on yielding of the mild steel dowels (position 3) developed into the "shear plug" and into the pile cap.

Note:

The term "shear plug" detail (Figures 6a and 6b) denotes composite concrete section developed into the pile and pile cap. The shear plug is designed to provide pile to pile cap connection at the pile to pile cap interface.

Steel pipe shear plug detail more appropriate for high magnitude and intensity seismic loads is shown in Figure 6c.

The dowels of the shear plug (Figure 6a and 6b), however, yield not once, but multiple times during the cyclic movement. Predictability of the dowel elongation in such connections is next to impossible.

It is quite obvious that analysis and design for seismic events of Levels L2 and L3 relies on the cracked or partially plasrtisized concrete pile section, whilst rational design for seismic events of magnitude Level L1 must rely on the fully elastic reaction of the pile material. As it was stated above, predictability of the results based on POLA suggested pile to pile cap connection detail developed for precast prestressed concrete pile is questionable.

Therefore, discussion suggested below concentrates on analysis and design of the wharf framing with steel pipe pile sections only. It will be shown that design utilizing steel pipe sections for piles and shear plugs yields more predictable and accurate results.

Performance based analysis is based on performance (deflection) of the structure during the different seismic events. In turn performance based analysis allows 3 different design approaches:

a) Design of RIgid pier
b) Design of Flexible pier
c) Design of Semi-Flexible pier

- First approach creates extremely rigid structure with relatively high natural frequency, and very high lateral force induced by a seismic event.
- Second approach leads to a structure with partially plastisized connection details or partially plastisized piles. Such piers are softer and experience lower lateral force acting on the pile bent, however, large seismic event frequently leaves residual deformations in the pier structure.
- The last approach is the most rational one. It allows design of the semi-flexible pier for Base Shear that is significantly lower than the Base Shear acting on the rigid structure but slightly higher than the Base Shear acting on the partially plastisized flexible pier.

Resulting structure might experience certain anticipated, but manageable and easily repairable damage within the secondary elements, the damage similar to the damage experienced by the flexible pier structure, but of smaller magnitude.
And as always, “Devil is in the details”.

Ductility of the connection detail.

The factor frequently neglected during the design stage of the project is investigation of the pile to pile cap connection ductility. Ductility of the pile connection and proper detailing allow better predictability of the framing system deformations during and after the seismic event.

Obviously, preferred design would dictate design of the semi-flexible structure. However, in certain cases flexible structure might provide a good alternative design leading to small and justifiable plastic deformations.

Figure 2a, 2b and 2c show plastic hinge geometry and analytical model utilized for Direct Displacement Design Method.

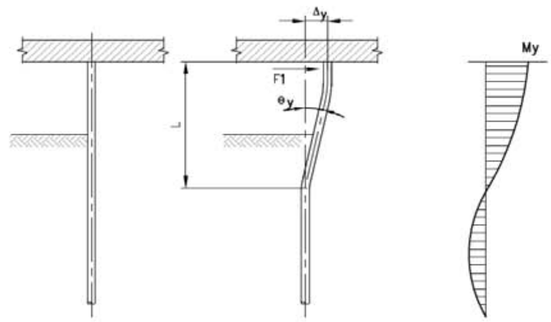


FIG. 2a

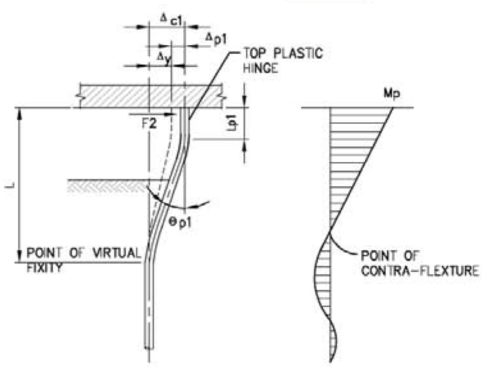


FIG. 2b

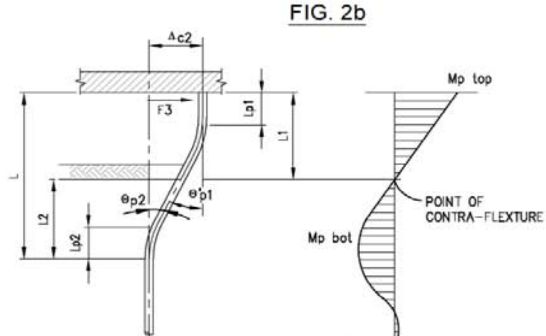


FIG. 2c

PLASTIC HINGE GEOMETRY

Plastic rotation at the Level L2 or L3 event can be determined from the following equation

$$\theta_p = L_p*(\kappa_p - \kappa_y) \qquad \textit{(Formula 2)}$$

Where,

κ_p – curvature corresponding to the plastic hinge at Level L2 or L3 seismic event

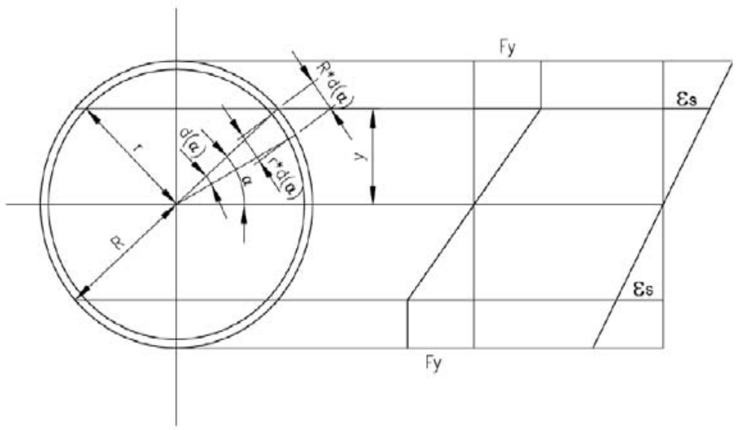
κ_y – curvature corresponding to a yield point

Generic expression for the curvature of partially plastisized pipe section can be determined from the formula 3:

$$\kappa_p = \varepsilon_y / y = (F_y / E_s) / [R_{ave}*\sin(\alpha)] \qquad \textit{(Formula 3a)}$$

$\kappa_y = \varepsilon_y / y = (F_y / E_s) / R_{ave}$ *(Formula 3b)*

Figure 3 describes all parameters utilized in *Formulas 3a and 3b*:



PIPE PILE PLASTIFICATION

FIG. 3

Where,

$R_{ave} = 1/2(R+r)$ – the average radius (the distance from the pipe pile center to the wall mid thickness)

$\varepsilon_y = F_y / E_s$ – strain corresponding to the yield point

L_p – length of the plastic hinge. Hinge length is restricted by stress boundaries where stress is exceeding yield stress, F_y

Pile deflection immediately prior to yield point, or development of the plastic hinge at the pile head.

$$\Delta_y = \theta_y * L \quad or \quad \theta_y = \Delta_y / L \qquad \text{(Formula 4)}$$

Pile deflection after development of the first plastic hinge at the soffit.

$$\Delta_p = \theta_{p1} * (L - 0.5L_p) \qquad \text{(Formula 5)}$$

Note 1:

Point of pile virtual fixity (PVF) approach may be used for preliminary analysis during the FEED study, but shall be avoided for final design. PVF shall be taken as a point where full fixity of the pile produces the same deflection results as the deflection results obtained from the elastic foundation (EF) model. As a conservative approximation, the point of virtual fixity can be taken as a 0-deflection point in the elastic foundation model.

Pile displacement capacity should be determined using upper and lower bound p-y curve soil limits utilizing elasto-plastic behavior of the pipe section.

The displacement capacity of the pile at the level of the top or in ground plastic hinge, whichever is smaller shall be determined as follolws:

$$\Delta_c = \Delta_y + \Delta_p \qquad \text{(Formula 6)}$$

Where,

Δ_c – total displacement capacity

Δ_y – elastic displacement, or displacement developed between the initial position of the pile and formation of the plastic hinge.

Δ_p – plastic displacement

For reasonably short piles where ratio of in-ground plastic moment ($M_{p\ in\ ground}$) to pile head plastic moment ($M_{p\ head}$),

$$M_{p\ in\ ground} / M_{p\ head} < 1.25$$

the distance from the point of contra flexure to the middle of the in-ground and top plastic hinges will be almost identical, and therefore plastic displacement for that condition can be reasonably accurately described by *Formula 7:*

$$\Delta_p = 2\theta_p * (0.5L_1 - 0.5L_p) \qquad \text{(Formula 7)}$$

Where,

L_1 – the distance between the point of contra flexure and the pile head.

Both, Δ_y and Δ_p are determined from the pushover analysis with pipe section undergoing transformation from the fully elastic to partially plastisized section.

III. Basics of the Elasto-Plastic Behavior of the Pipe Sections

For calculating deflection within the elasto-plastic mode, the designer shall calculate a new moment of inertia for the pipe pile section. I_{eff} is a variable parameter depending on the extent of the plasticized extremities of the steel pipe section. The step by step analytical procedure for calculation of the Effective Moment of Inertia and Ultimate Flexural

Capacity of the partially plastisized pipe section is offered below:

1. Calculate Effective Moment of Inertia of the pipe section with

$O.D = 2R$ and

$I.D. = 2r$.

Pile t(hickness) $= R-r$

2. Define the angle between the neutral axis and the edge of the slice, (α), as shown in *Figure 3*.
3. Chords confined by a small increment $d\alpha$:

Exterior and interior archs of the pipe confined by $d\alpha$ can be approximated by a chord length,

$R * d(\alpha)$ *(Formula 8)*

$r * d(\alpha)$ *(Formula 9)*

4. Area of the pipe shell confined by d (α):

$dA_i = 1/2 * (R+r) * t * d(\alpha)$ *(Formula 10)*

5. Distance from the neutral axis to the elementary area,

$y_i = y_\alpha = 1/2 * (R+r) * \sin(\alpha)$ *(Formula 11)*

6. The moment of inertia of the pipe section confined by the central angle (α) in each of the 4 quadrants is,

$$I_{eff} = 2\int y_i^2\, dA_i = 2((R+r)/2)^3 * t * \int_{-a}^{\alpha} \sin^2(\alpha) * d(\alpha)$$

$$I_{eff} = 1/4 * (R+r)^3 * t * [0.5 * \alpha - 0.25 * \sin 2(\alpha)] \Big| \text{ over integration limits} \qquad \text{(Formula 11)}$$

For checking formula, set integration limits between $(\pi/2)$ and $(-\pi/2)$ for fully elastic section:

$$I_\alpha = I_{a\ eff} = 1/4 * (R+r)^3 * t * [0.5 * \alpha - 0.25 * \sin 2(\alpha)] \Big| = 0.25 * (R+r)^3 * t * (1.57) \qquad \text{(Formula 12)}$$

7. Using Formula 11, designer can determine the central angle (α) corresponding to the flexural demand.

8. Elastic section modulus. (Elastic Section Modulus varies with central angle α)

$S_\alpha = I_{\alpha\ eff} / y_\alpha$ *(Formula 13)*

Where,

I_α and y_α are effective moment of inertia $(I_{\square eff})$ and (y) corresponding to a central angle (α)

9. Moment taken by elastic portion of the section

$M_{el} = F_y * S_\alpha$ *(Formula 14)*

Plastic section modulus, $Z = \Sigma dA_i * y_i$

$$Z_\alpha = 4\int y_i * dA_i = 2 * 0.5 * (R+r)^2 * t * \int_0^{\pi/2} \sin(\alpha) * d(\alpha)$$

$$Z_\alpha = -1.0 * (R+r)^2 * t * \cos(\alpha) \Big| \text{ over integration limits} \qquad \text{(Formula 15)}$$

For checking formula, set integration limits between $(\pi/2)$ and (0) (fully plastic section)

$Z_\alpha = (R+r)^2 * t$ *(fully plastic section)* *(Formula 16)*

Moment taken by a plastisized portion of the section

$M_{pl} = Fy * Z_\alpha$ *(Formula 17)*

10. Total moment capacity of the section is determined from Formula 18

$M_{el\text{-}pl} = F_y * (S_\alpha + Z_\alpha)$ *(Formula 18)*

Step 10 concludes analysis of partially plastisized pipe section.

Example 1.

Example 1 shows analysis of the partially plastisized pipe section in a tabular format below.

Table 1 : (Moment Capacity of Elastic Portion of the Pipe Pile Section)

PLASTISIZED PIPE SECTION

R =	744	mm	=O.D/2
r =	725	mm	=I.D./2
t =	19	mm	wall thickness
F_y=	344	Mpa	

*I_{eff} = 1/4 * $(R+r)^3$ * t * [0.5 * a – 0.25 * sin2(a)]*
*a_1 =0.25*t(R+r)*
*k_1 = [0.5 * a – 0.25 * sin2(a)] integration limits a to -a*
*I_{eff} = a_1 * k_1*

ELASTIC PART OF THE PIPE SECTION

α (deg)	α (rad)	k_1	a_1= = 0.25*t*$(R+r)^3$	I_{eff} (mm4)	y (mm)	S_α (mm^3)	$M_{el} = F_y*S_\alpha$ (kN-m)
90	1.57	1.571		2.3653E+10	744	31,791,128	10,936
89	1.55	1.536		2.3127E+10	744	31,089,465	10,695
88	1.54	1.501		2.2602E+10	744	30,397,280	10,457
87	1.52	1.466		2.2077E+10	743	29,714,378	10,222
86	1.50	1.431		2.1554E+10	742	29,040,578	9,990
85	1.48	1.397		2.1031E+10	741	28,375,712	9,761
84	1.47	1.362		2.0510E+10	740	27,719,623	9,536
83	1.45	1.328		1.9992E+10	738	27,072,165	9,313
82	1.43	1.293		1.9475E+10	737	26,433,203	9,093
81	1.41	1.259		1.8961E+10	735	25,802,612	8,876
80	1.40	1.225		1.8450E+10	733	25,180,276	8,662
10	0.17	0.004		53,046,115	129	410,592	141
9	0.16	0.003		38,715,419	116	332,643	114
8	0.14	0.002		27,219,258	104	262,874	90
7	0.12	0.001		18,251,451	91	201,294	69
6	0.10	0.001		11,502,733	78	147,909	51
5	0.09	0.000		6,661,137	65	102,726	35
4	0.07	0.000		3,412,373	52	65,750	23
3	0.05	0.000		1,440,209	39	36,987	13
2	0.03	0.000		426,859	26	16,440	6
1	0.02	0.000		53,367	13	4,110	1
0.001	0.00	0.000		0	0	0	0

Table 2 : (Plastic Section Modulus)

Z_α = –1.0*(R+r)2 *t *cos(α)
k_2=cos(α) integr limits π/2 to 0
b = –1.0*t*(R+r)^2

Table 3 : (Moment Capacity of Plastisized Portion of the Pipe Pile Section)

PLASTISIZED PART OF THE PIPE SECTION

α (deg)	α (rad)	k_2	b= -1.0*t*(R+r)^2	Z_α (mm^3)	M_{pl} = Fy*Z_α (kN-m)
90	1.57	-1.000		41,001,259	14,104
89	1.55	-0.983		40,285,688	13,858
88	1.54	-0.965		39,570,336	13,612
87	1.52	-0.948		38,855,419	13,366
86	1.50	-0.930		38,141,156	13,121
85	1.48	-0.913		37,427,764	12,875
84	1.47	-0.895		36,715,460	12,630
83	1.45	-0.878		36,004,462	12,386
82	1.43	-0.861		35,294,987	12,141
81	1.41	-0.844		34,587,249	11,898
80	1.40	-0.826		33,881,465	11,655
10	0.17	-0.015		622,901	214
9	0.16	-0.012		504,794	174
8	0.14	-0.010		399,021	137
7	0.12	-0.007		305,617	105
6	0.10	-0.005		224,609	77
5	0.09	-0.004		156,022	54
4	0.07	-0.002		99,877	34
3	0.05	-0.001		56,191	19
2	0.03	-0.001		24,977	9
1	0.02	0.000		6,245	2
0.001	0.00	0.000		0	0

Table 4 : (Moment Capacity of Partially Plastisized Pipe Pile Section)

EXAMPLE:

Calculate maximum moment capacity of the partially plastisized section with (a) = 80 deg = 1.40 rad

α =	1.4	rad	plastification angle
M_{el} =	8,662	kN-m	@ α = 1.40
M_{pl} =	2,449	kN-m	= $\mathbf{M}_{pl\ @\pi/2} - \mathbf{M}_{pl\ @1.40}$
$M_{el\text{-}pl}$ =	11,111	kN-m	= $\Sigma(\mathbf{M}_{el} + \mathbf{M}_{pl})$
I eff =	1.8450E+10	mm^4	= **I** eff @ α =1.40

Pushover analysis should indicate moment demand at every plastic hinge under review (*Figure 1*

Pier performance shall be based on effective moments of inertia along the pile length, including moments of inertia based on partially plastisized sections. Considering that some length at the top of the pile and part of the pile above and below the point of virtual fixity will consist of composite telescopic sections, location of the plastic hinge shall be determined from the three side by side diagrams: Moment diagram, M; Composite Section Modulus diagram, S; and M / S diagram.

The boundaries of the plastic hinge were defined in Section II above.

Note 2:

The length of the hinge is defined by the length of the pile where stress exceeds steel Yield Stress, F_y. Pile length within the effected plastic hinge area can be divided in several stepped sections for which designer can calculate composite pile moment capacity and effective moment of inertia using procedures outlined in Example 1.

Figure 2 indicates possible locations of the plastic hinges within the pile length. These areas can be effectively reinforced by a telescopic pile insert of smaller diameter extended into the pipe pile and into the soil socket at the bottom of the pile; and by a shear plug insert pipe at the level of the top plastic hinge. Such details, if done properly (*Figure 4*), may deliver pier structure with marginal level of plastification and very little residual deflection, if any.

IV. Shear Plug Function and Shear Plug Analysis

Shear plug is a short pile element utilized as a transition connector between the pile and a pile cap. Shear plug analysis and design were discussed in "Seismic Design of Pile to Pile Cap Connections in Flexible Pier Structures."[2]

Concept of the pile to pile cap connection modeling shall be based on the following assumptions:

I. Shear plug shall be treated as a short inverted pile fixed within the pile and embedded into the rigid concrete medium of the pile cap. (*Figure 4*)

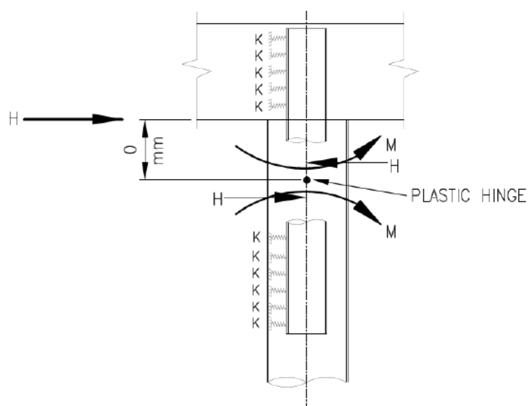
II. Concrete P-Y curves for concrete can be reasonably approximated by the P-Y curves for hard clay,

Note 3:

Frame analytical model in that case is built on assumption that pile is directly attached to the pile cap at the pile cap mid height. Effect of the strain penetration into the pile cap is negligent. Nevertheless, shear plug prying effect within the pile cap must be investigated.

Figure 4 shows Shear Plug Elastic Foundation model for upper (above the pile / pile cap interface) and lower (bodies of the Shear Plug separated by the plastic hinge. Due to the Shear Plug confinement within the pile cap and pile itself, it can be predicted that the plastic hinge develops at the section having the smallest section modulus: at the pile/pile cap interface.

III. Shear Plug embedment into the pile must be treated as a beam on elastic foundation. Pile ovalization due to the shear plug prying action must be investigated and shear plug embedment into the pile must be determined from the model analysis.



SHEAR PLUG ELASTIC FOUNDATION MODEL

FIG. 4A

Springs values for shear plug Elastic Foundation supports within the pile itself are determined from the half pipe model shown in <u>*Figure 5*</u>.

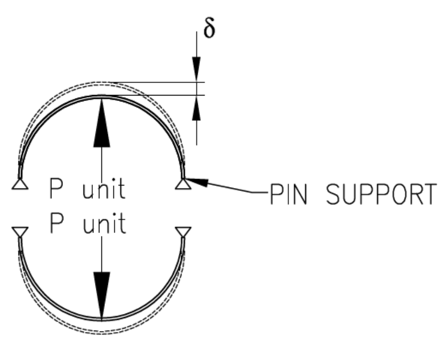
$$k = P/\delta$$

Where,

P – is a unit load. Unit load in that model is applied at the center of the section.

For convenience of analysis unit load can be of any arbitrary value that does not produce stress above the yield limit of the section material.

δ – is elastic deformation of the section (elastic ovalization)



ELASTIC FOUNDATION SPRING ANALYSIS.

FIG. 5

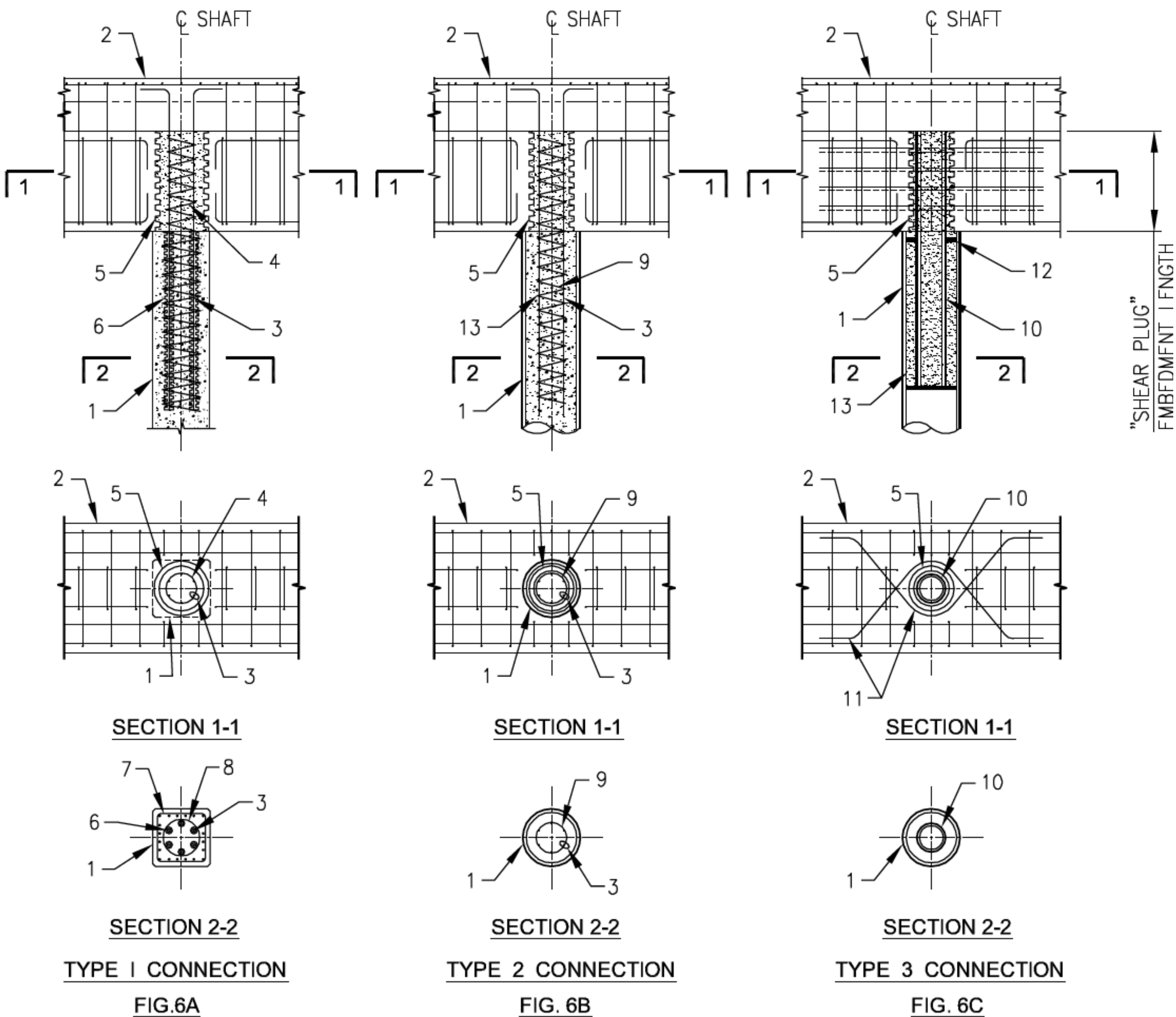
If results of that analysis show that pile material yields or experiences excessive deformations, pipe section might require some form of reinforcement. One option for such reinforcement is shown in Fig. 6c where interior stiffening ring (12) is welded on the interior perimeter of the pipe pile. It would be advisable to weld such ring within 70 to 100 mm from the pile cut off.

Pipe Section Shear Plug vs. Caged Dowel Shear Plug.

Importance of the proper shear plug detailing is shown below.

Figure 6a, 6b, 6c show several detailing options for shear plug connection

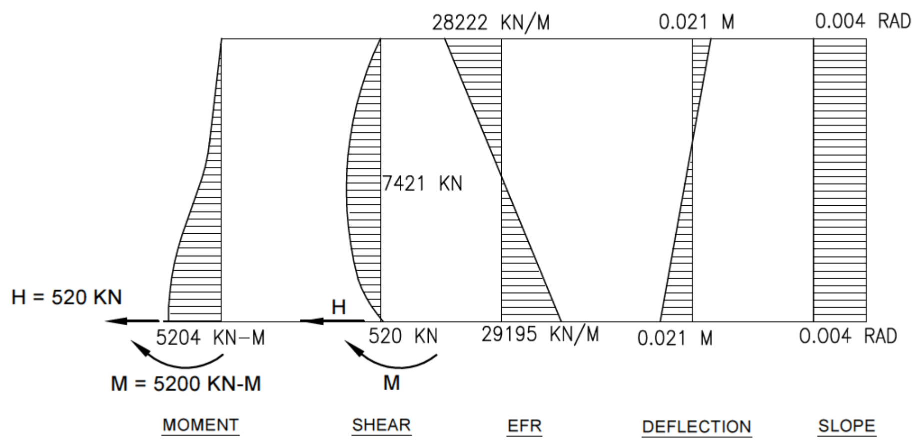
Connections of Type 1 and Type 2 are not recommended for high seismic zones.



1. PRECAST PILE OR STEEL PIPE PILE
2. PILE CAP
3. DOWEL OF THE "SHEAR PLUG INSERT"
4. SPIRAL OF THE "SHORT PILE" WITHIN PILE CAP
5. SOCKET SLEEVE
6. DOWEL SLEEVE
7. SPIRAL OF THE PRECAST PILE
8. SPIRAL OF THE "SHORT PILE" WITHIN PRECAST PILE
9. SPIRAL OF THE "SHEAR PLUG INSERT"
10. SHEAR PLUG INSERT WITH CLOSURE PLATE
11. HORIZONTAL Ω – STIRUP
12. RING STIFFENER PLATE
13. CONCRETE INFILL

Figure 7 : shows generic force diagrams for analysis of the Shear Plug embedment into the pile cap

The shear plug design shall satisfy 2 design parameters outlined below:



FORCE AND DEFLECTION DIAGRAMS

FIG. 7

- Satisfactory plastic moment capacity of the shear plug.
- Shear plug embedment into the pile shall be adequate for prevention of the pile ovalization at the pile /pile cap interface.

Shear plug can be considered to be fully adequate if plastification angle (α) does not exceed 80 deg. The angle size was selected arbitrarily for maintaining marginal safety of the design. Importance of the shear plug detail cannot be underestimated.

It shall be explained that connection details of Type 1 and Type 2 can be successfully used in areas with mild to moderate seismic activity.

Type 3 shear plug connection was designed for regions with high PGA and seismic intensity. Shear plug confinement within the pile cap, in that connection, is provided by series of Ω-stirrups (11) equally spaced along the height of the pile cap section, and pile ovalization at the top of the pile may be arrested by the circular donut stiffener (12) intermittently welded to the pile perimeter. Alternatively pile section geometry can be checked against plastic deformations using the half pipe model shown in *Figure 5*.

Photograph 1 shows pile cap failure due to the lateral shear force. Such failure would be typical for pile caps inadequately reinforced in lateral direction. Type 3 connection detail shown in Figure 6c shows a system of mirrored ***Ω-stirrups*** anchoring shear plug in both directions perpendicular to the pile cap longitudinal axis. During the structure movement at least 1/2 of ***Ω-stirrups*** resisting horizontal seismic force will be anchored within the pile cap compression zone, resisting the block rupture shown in *Photograph 1*. The ***Ω-stirrups*** should be always complemented by conventional closed stirrups placed in vertical direction.

Size of the *Ω–stirrups* can be determined from the Elastic Foundation Reactions (EFR) at each spring position.

Photograph 2 shows pile head plastic hinge failure.

This photograph is self explanatory and shows deficiency of ordinary shear plug details of type 1 and 2 for regions with high seismic activities.

PHOTO 1

PHOTO 2

For a neutral observer it is quite obvious that doweled shear plugs are less reliable than a shear plug formed from the pipe section of the comparable diameter, provided shear plug embedment length is adequately designed for prevention of section ovalization at the pile head.

V. Moment Capacity and Effective Moment of Inertia of Composite Pile Section

In telescopic pile details where smaller diameter pipe pile is overlapped with larger diameter starting pile the length of overlap shall extend at least 3 insert pile diameters beyond the point where I_{eff} of the partially plastified starting pile combined with an elastic moment of inertia of the insert pile, $I_{ins\ elast}$:

$$I_{tot} = I_{eff} + I_{ins\ elast} \qquad \text{(Formula 19)}$$

produce deflection of the pier of wharf structure that will be in compliance with performance requirements of the seismic event. The plastification angle (α) for starting pile shall not be taken less than 80 deg.

VI. Overload Factors and Ductility of the System

The following load factors for the limit state design method shall be used depending on the pile capacity to resist overloads by plastic yielding or by forming plastic hinge:

- *No yielding possible, $\gamma = 1.25$*
- *Yielding possible until a displacement of at least two times the maximum elastic displacement, $\gamma = 1.00$ "*

For piles undergoing elasto-plastic deformations which are less than twice the elastic deflection based on gross moment of inertia of the affected piles, overload factor γ shall be interpolated.

Possibility of overload of an essentially elastic *Capacity Protected Element* (CPE) is strong when pile material does not reach the yield point within the two times the max elastic deflection. Forces acting on the pile at the level of the pile cap soffit are than determined from the following equations[3]:

$$M_o^{\ pile} = \gamma * M_p^{\ pile} \qquad \text{(Formula 20)}$$

$$V_o^{\ pile} = 2 * M_o^{\ pile} / L_c \qquad \text{(Formula 21)}$$

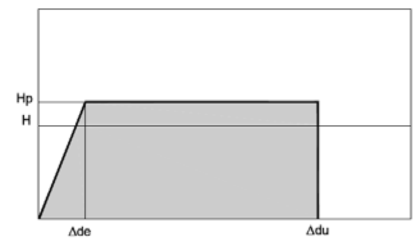
Where,

M_p – pile plastic moment capacity, at the location of the first plastic hinge.

If the shear plug was designed as a composite reinforced concrete section, it is expected that the first plastic hinge will develop at, or slightly below, the soffit of the pile cap.

L_c – the distance between maximum moments in the pile (distance between the pile cap soffit and point of pile virtual fixity)

Figure 8 shows the Force vs. Deflection Graph where maximum ultimate deflection *(Δ_{du})* is limited by the ability of the single wharf bent to absorb plastic deformations without losing stability. The ratio of the max displacement *(Δ_{du})* to the elastic displacement of the bent *(Δ_{de})* is called bent ductility factor *(μ_D)*.



FORCE VS. DEFLECTION GRAPH

FIG. 8

$$\mu_D = \Delta_{du} / \Delta_{de} \qquad \text{(Formula 22)}$$

Where,

Δ_{de} - maximum deflection of the fully elastic section

Δ_{du} - deflection of the fully plastic section prior to failure

Note: *Δ_{du} can be substituted for any arbitrary deflection corresponding to a selected partially plastisized section. That will artificially reduce full ductility* to a performance ductility.

Equating the work done by the hypothetical external force (H) to the energy absorbed by the bent:

$$H*\Delta_{du} = 0.5H_p*\Delta_{de} + H_p*(\Delta_{du} - \Delta_{de}) \qquad \text{(Formula 23)}$$

Where,

$H*\Delta_{du}$ – is work done by a hypothetical impact force *(H)*

$0.5H_p*\Delta_{de} + H_p*(\Delta_{du} - \Delta_{de})$ – Energy absorbed by a bent prior to being forced into instability.

Rewriting *Formula 19* in terms of H_p/H:

$$H_p / H = 2\mu_D / (2\mu_D - 1) \qquad \text{(Formula 24)}$$

Formula 24 establishes the relationship between the bent Capacity *(H_p)* and Demand Load *(H)*,

Where *H* is the maximum anticipated load.

The ductility factor applies only to flexible partially plastisized pile supported systems, but does not have any physical meaning for semi-flexible systems exhibiting fully elastic behavior.

The Base Shear acting on the structure will be reduced by the ductility effect factor.

$$V_{BS} = C_{sm} *W / \mu_D \qquad \text{(Formula 25)}$$

Where,

C_{smi} –is an Elastic Seismic Response Coefficient or Spectral Response Acceleration of the single transverse pile bent to the seismic event.

W – weight attributed to the pile bent during the seismic event.

C_{smi} – is magnified acceleration depending on the ratio of forcing frequency to first natural frequency of the structure

$$C_{smi} = PGA * Q$$

The amplitude of the Response or Force Magnification Factor, Q is described by *Formula 26*[4]:

$$Q = 1 / [(1-\Omega^2)^2 + (2\vartheta * \Omega)^2)]^{1/2} \qquad \text{(Formula 26)}$$

Where,

$\Omega = f_f / f_m$ – ratio of the forcing frequency, (f_f) to natural frequency of the wharf f_m

and

ϑ – is damping ratio. For properly detailed bent with steel piles the damping ratio, $\vartheta = 0.015$

If :

$\Omega = f_f / f_m$ ====> 0 the structure response approaches the static response where displacement is controlled by the stiffness of the spring, (k) rather than by mass or damping.

$\Omega = f_f / f_m = 1$ structure starts to resonate, and if structural damping is zero, dynamic magnification attains infinity.

$\Omega = f_f / f_m > 1$ the structure response starts to approach static response again, but in this case structure response is controlled by mass.

In other words, the acceleration of the structure will be scaled up or down from the Peak Ground Acceleration, PGA (horizontal acceleration of the absolutely rigid structure or structure having 0-sec Natural Period) depending on the softening or stiffening effect of the structure.

The damped Natural Frequency can be determined from *Formula 27*:

$$f_m = 0.5\pi * [k/m * (1- \vartheta^2)]^{0.5} \qquad \text{(Formula 27)}$$

The explains the physics of the response spectra acceleration and how response spectra graphs are built by geotechnical engineers.

The following describes the steps necessary for estimating Fundamental Period of the wharf structure in longitudinal direction, T_{m2} and eccentricity of application of the orthogonal inertia force, e_{BS2}:

Step 1. Estimate the spring value of each longitudinal pile bent, $k_i = P/\delta$

Step 2. Calculate Fundamental Period of the whole wharf in longitudinal direction

$T_{m2} = 2\pi*(m_{tot} / \Sigma k_i)^{0.5}$ ====> Determine Spectral Response Acceleration C_{sm2}

Where, (m_{tot}) is the total mass of the wharf.

Step 3. Estimate average ductility of the sum of the longitudinal bents, μ_a

Total inertia force in longitudinal direction,

$$V_{BS2} = C_{sm2} * W / \mu_a$$

The base shear attributed to each longitudinal pile bent

$$V_{BSi} = V_{BS2} * (k_i / \Sigma k_i)$$

Note 4:

It is recommended to design Fundamental Periods of adjacent longitudinal bents such that they satisfy the following requirement[3]*:*

$$T_i / T_{i+1} > 0.5 \text{ to } 0.7$$

That provision was designed with the purpose of eliminating excessive twisting of the wharf deck Position of the inertia force in the transverse direction can be estimated from the following formula:

$$y_{BS} = \Sigma V_{BSi} * y_i / \Sigma V_{BSi}$$

Eccentricity of the longitudinal inertia force,

$$e_{BS2} = y_{C.L.} - y_{BS}$$

Final adjustment to the base shear attributed to each transverse direction pile bent

$$\Delta V_{BS1} = [V_{BS1} * (e_1) + V_{BS2} * (e_2 + e_{BS2})] * (x_i / \Sigma x_i^2)$$

Where,

$\Sigma x_i^2 = I_p$ - polar moment of inertia of the wharf transverse pile bents. Each pile bent is

treated as a line.

y_i – is the y- coordinate of the longitudinal pile bent.

$y_{C.L.}$ – is the y-coordinate of the deck centerline.

x_i – position of the transverse bent vs. deck centerline, taken as an absolute value.

e_1 – accidental eccentricity of the transverse inertia force.

e_2 – accidental eccentricity of the longitudinal inertia force.

ΔV_{BSi} - is an inertia force increment due to the base shear eccentricity.

VII. Gravity Component of the Inertia Force

The average live load on the deck (total live load divided by the area of the wharf deck) rarely exceeds 35 to 45% of the specified design live load.

Assuming, conservatively, the dynamic friction coefficient between the live load and the wharf deck, $\mu_d = 0.3$, the horizontal live load component of the inertia force acting on the pile bent should be based on 10% to 12% of the L.L. contribution.

Gravity load acting on the pile bent shall include

$$N = X\% \ L.L. + D.L.,$$

Where, *"X"* can vary from 0 to 100%

Whilst Inertia force acting on the same bent

$$V_{BS} = (45\% \ L.L. * \mu_d + D.L.) * C_{sm}$$

VIII. Slope and Wharf Stability

Free Field Dike Deformations

Free Field Dike deformations in absence of piles can be determined utilizing simplified Newmark sliding block. Newmark method yields reasonably accurate results for short slopes where analytical assumption that all vertical slices of the dike are moving in the same direction is reasonable. For long slopes that method will be extremely conservative as different vertical slices along the slope will have different Natural Periods and might move in opposing directions at each instance.

POLB recommends seismic coefficient of 0.33*PGA or 0.15 g, whichever is greater, for analyzing pseudo-static seismic slope stability. Pile pinning effect shall not be considered.

That assumption is explained by compatibility of slope lateral deformations and lateral forces exerted by the sliding dike on the pinned piles.

Where slope lateral deformation induces lateral force that displaces pile bent beyond the specified performance limits and / or moment or shear in the pile exceeds 90% of the pile ultimate capacity, the size of the piles and pile bent geometry will require revision.

POLB does not differentiate between the load in the backstage area at Operating Level Earthquake and Design Level Earthquake, whilst ASCE 7-10 treats these loads as transient loads applying reduction factor of 0.75 to the backstage surcharge loads.

Pseudo-static seismic slope stability analysis at the Design Level Earthquake (DLE) and Maximum Considered Earthquake (MCE) shall utilize only 75% of the surcharge load used in the static load analysis. Such reduction in the surcharge load within the backstage area at the time of the maximum seismic event is justified by the extremely low probability of both loads acting simultaneously.

Mononobe-Ocabe formula coupled with modified Boussinesq equations shall be utilized for estimating additional pressure on the cut off wall from the seismic effect of the backstage area. The load from the cut off wall shall be traced to the wharf framing structure.

Note 5:

Factor of Safety, F.O.S. for static slope stability shall not be less than 1.5

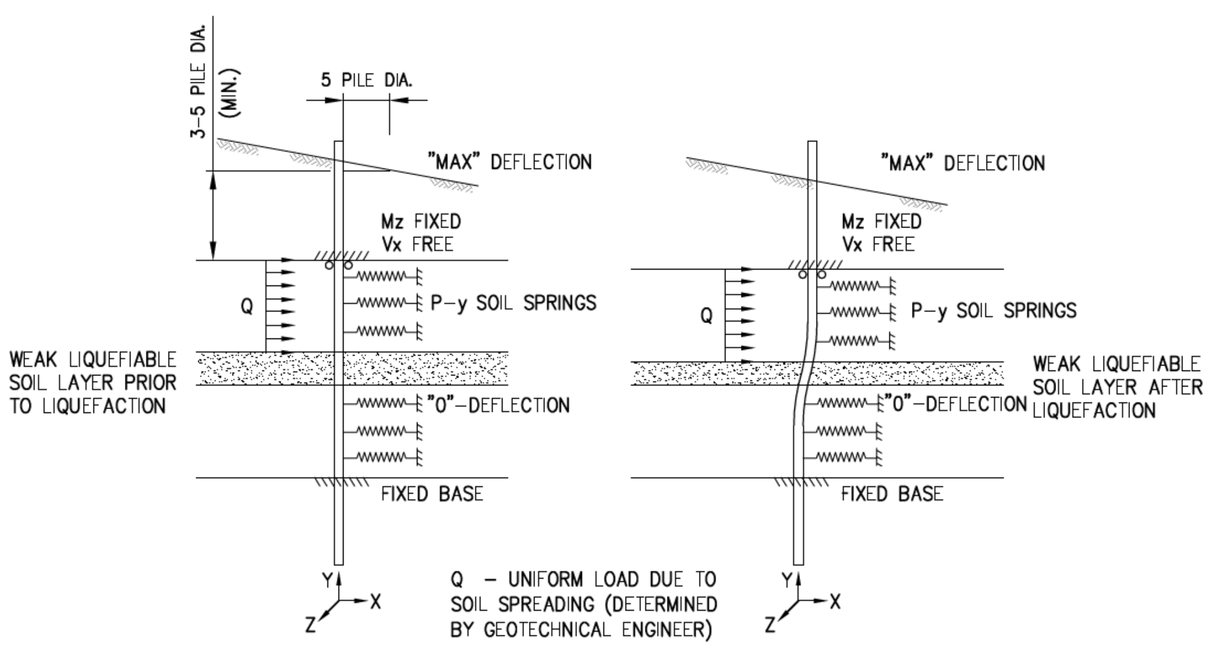
Whilst pseudo-static seismic slope stability shall be not less than 1.1

If the estimated F.O.S. for pseudo-static seismic slope stability exceeds 1.1, no pile –slope interaction kinematic analysis is required.

Modeling Kinematic Loading on the Piles

Note 6:

Inertia and kinematic loading occur at different instances of the seismic event; therefore, pile flexural analysis based on slope movement shall be decoupled from the pile flexural analysis based on the deck inertia forces.



KINEMATIC ANALYSIS. SLIDING WEDGE MODEL

FIG.9

The following support boundaries shall be used for kinematic model.

- Fully fixed base at the bottom. Fixity at the bottom shall be placed at a distance not less than 10 pile diameters from the bottom of the weak layer.
- Rotational fixity at the top shall be placed at a distance not less than 3 to 5 pile diameters from the top of the weak layer (3 pile diameters for pile diameters less than 762mm, and 5 pile diameters for piles with diameter up to 1524mm)

POLA/POLB sets the following criteria for concrete piles:

If the estimated Displacement Demand of the slope calculated by the Geotechnical Engineer is less than Displacement Capacity of the pile, no further analysis is required. Otherwise, the pile size or pile bent framing should be modified.

That statement is irrelevant for structures supported on steel pipe piles.

Modified statement rewritten for wharves supported on steel pipe piles will be significantly more relaxed:

- Fully elastic response of the wharf structure to seismic events of level L1 shall be expected.
- Development of full or partially developed plastic hinges in the piles during seismic events of magnitude L2 are governed by performance requirements set for designed structure.
- The forces exerted by the spreading of the dike soil on the piles shall not exceed 80% of the ultimate capacity of the piles providing residual stability of the wharf framing. This requirement is mostly irrelevant for seismic events of level L2, but important for seismic event of level L3, setting a single structural requirement: wharf structure should not collapse during or after extreme seismic event.

In other words, extreme seismic event shall not create fully developed plastic hinges endangering wharf stability.

IX. Liquefaction as a Surge Protector

It is important to remember that liquefaction frequently works as a “surge protector”:

While it increases pile effective length, it simultaneously reduces bent lateral stiffness, $k_i = H / \delta$ increasing Natural Period of the structure, $T_m = 2\pi * (m/k_i)^{0.5}$

That in turn reduces Spectral Response Acceleration C_{sm} and corresponding Base Shear,

$V_{BS} = C_{sm} * W / \mu_D'$

Where,

μ_D' – modified ductility of the pile bent.

Forces in the wharf and wharf performance after projected liquefaction must be recalculated.

X. Deck Span. Effect of Vertical Acceleration

The effect of the vertical acceleration becomes significant only when the induced force frequency is comparable with the span fundamental frequency. That is not the case for short and rigid spans of the wharf deck having fundamental frequencies, (f_m) 3 to 5 times higher than the frequencies of the dominant seismic waves, (f_f) Dynamic Magnification in that case is between 4 and 12%:

$Q = 1 / [(1-0.2^2)^2 + (2*0.01*0.2)^2)]^{1/2} = 1.04$ when $\Omega = f_f / f_m = 1/5 = 0.2$

$Q = 1 / [(1-0.33^2)^2 + (2*0.01*0.33)^2)]^{1/2} = 1.12$ when $\Omega = f_f / f_m = 1/3 = 0.33$

It would be conservative to include 10% weight increase for analysis of the deck structure for total gravity load.

XI. Summary. why Steel Pipe Piles?

Steel piles have well defined hysteresis curves and well defined plastic hinges with high level of ductility. That makes them a perfect material for construction in regions with high seismic forces.

Corrosion Protection of Steel Piles.

Typical line of defense against corrosion is epoxy coating coupled with cathodic protection. However, cathodic protection works only under submergence. The cons of cathodic protection are frequently neglected. Cathodic protection compatibility with coating must be always investigated. Cases of coating disbondment caused by effects of cathodic protection are well known.

The following is the list of products which showed excellent results in the offshore construction:

- Denso Shield Marine Pile Protection System.
- Archo Rigidon Coating & Linings

The first system consist of the complete wrapping of the effected pile surface, cutting exposure oxygen and salts; and second system consist of special coating which allows up to 40 mils of coating application in one coat. The Archo Rigidon Coating showed high sea water resistance, high temperature tolerance and abrasion resistance and showed excellent compatibility with cathodic protection (low disbondment results).

Some cementitious epoxy coatings containing aluminum powder showed excellent results as the stand alone systems, but indicated very poor compatibility with cathodic protection.

XII. Acknowledgement

Dedication: This article is dedicated to a memory of late Ron Joseph Mancini, P.E. of Mancini Shah Associates, engineer, researcher, amazing person, mentor and friend.

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Characterization of the Radar Waves Gpr by Digital Simulation for the Auscultation in Civil Engineering

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Abstract- The numerical simulation of non-destructive testing of the materials has made considerable progress in the recent years. This simulation allows not only to increase the efficiency and the potential of the non-destructive testing methods, but also to expect the results of a particular technology and to define the most efficient conditions of achievement, while reducing the costs of progress. The purpose of this presentation is to show the important contribution of the computer simulation as regards the auscultation of the reinforced concrete slabs by GPR technique. The cases of the water infiltration and the chloride ions as well as the delaminations are considered.

Keywords: non-destructive methods; gpr technique; pathology of concrete structures.

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CHARACTERIZATIONOFTHERADARWAVESGPRBYDIGITALSIMULATIONFORTHEAUSCULTATIONINCIVILENGINEERING

Strictly as per the compliance and regulations of :

Characterization of the Radar Waves GPR by Digital Simulation for the Auscultation in Civil Engineering

R. Obad [α], M. Afifi1 [σ], H. Ait Benamer [ρ] , O. Moudden [Ѡ] & A. Salhami [¥]

Abstract- The numerical simulation of non-destructive testing of the materials has made considerable progress in the recent years. This simulation allows not only to increase the efficiency and the potential of the non-destructive testing methods, but also to expect the results of a particular technology and to define the most efficient conditions of achievement, while reducing the costs of progress. The purpose of this presentation is to show the important contribution of the computer simulation as regards the auscultation of the reinforced concrete slabs by GPR technique. The cases of the water infiltration and the chloride ions as well as the delaminations are considered.

Keywords: non-destructive methods; gpr technique; pathology of concrete structures.

I. Introduction

Among the current pathologies that affect the reinforced concrete structures is the increase of the corrosion. This corrosion is caused by the infiltration of water and chloride ions. The GPR technique is very practical in recent years to assess the probability of the increase of the corrosion in reinforced concrete elements according to two approaches. The first approach considers the attenuation of the waves reflection on the armatures or structures of the controlled parement and the second approach considers the waves reflection on the basis of the controlled reinforced concrete element. Furthermore, the detection of the delamination at the level of the upper structures is also performed according the two approaches mentioned above. The analysis of the records elements is based on the fact that the places where we record low reflections are the places where the possibility of corrosion is strong as well as the delamination. This article aims to choose the most reliable approach and this by means of the numerical simulation.

II. Pathology of Concrete Structures

a) Cracking

It is important, first of all, to emphasize that it is impossible today to avoid the cracking of the concrete, either during the implementation that is due, for example, to the drying shrinkage or on hardened concrete due the material aging. Thereafter, the corroded armatures which have a larger volume than the steel in good condition, the concrete pressure state in the place of a corroded reinforcement is more important and the cracking breaks. [1]

b) Concrete carbonation

The carbonation is a cause of corrosion of reinforced concrete structures and destabilizes their hardiness. It is a natural phenomenon of dissolution of the carbon dioxide from the air in the interstitial solution of the concrete, followed by acid-basis reaction with the basic compounds such as the portlandite, to form calcium carbonate. This results in a decrease in pH and reinforcement corrosion.

The relative humidity of the surrounding environment is a fundamental parameter. Indeed, in order that the process continues, we need a supply of humid carbon dioxide. However, the diffusion of the dioxide takes place 10,000 times faster in the air than in water. The relative humidity must be low enough that the release of carbon dioxide is possible, but it must also be sufficiently important for the occurrence of the carbonation reaction itself. [5]

The concrete carbonation is a slow phenomenon. Its speed depends on many factors such as the compactness, the percentage in the cement, the type of cement, the water content in the concrete, the degree of hydration of cement, the carbon dioxide concentration of the air, the relative humidity of the air, the temperature. More the carbon dioxide content of the air is higher; more the speed of carbonation is fast.

The influence of the compact is shown in Picture 1. The carbonation speed decreases when the quantity of water in the concrete decreases. Indeed, a reduction of the mixing water reduction reduces the porosity of the concrete, which slows the penetration of the carbon dioxide. The carbonation speed decreases also when the cement content increases [2].

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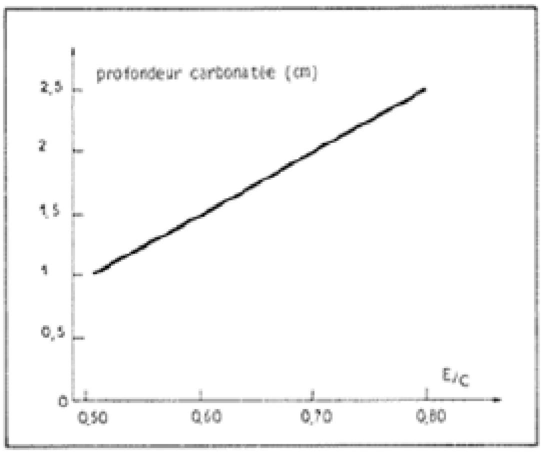


Picture 1: Influence of E / C rate on the carbonate depth after three years.

The reactions that may occur in ambient conditions are:

- Dissolution of iron using the anode:

$$Fe \longrightarrow Fe^{2+} + 2e^{-} \qquad \text{(Eq. 1)}$$

- corrosion of water using the cathode:

$$H_2O + 1/2\ O_2 + 2e^{-} \longrightarrow 2\,OH^{-} \qquad \text{(Eq. 2)}$$

- Migration OH- ions using the anode:

$$Fe^{2+} + 2\,OH^{-} \longrightarrow Fe(OH)_2 \qquad \text{(Eq. 3)}$$

A schematic representation of these reactions is noticed in Figure 2.

In the presence of oxygen excess, Fe (OH)2 is changed into Fe2O3 and FeO. According to the conditions, the composition of the oxidation products is variable and can be represented by the formula: (FeO) x (Fe2O3) (H2O)z [3].

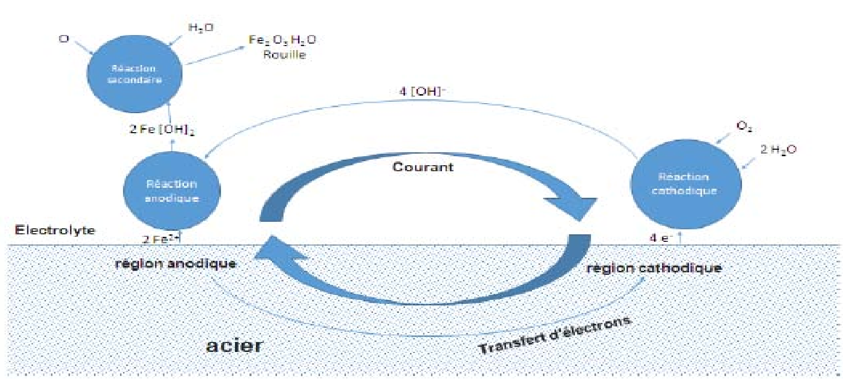
d) Causes of the corrosion

There are two main factors that contribute in the appearance of the corrosion in the reinforced concrete. Firstly, there is the concrete carbonation. When the pH of the concrete drops below 9; the armatures are no longer passivated. This phenomenon is caused by the reaction between the hydrate of the cement paste and the atmospheric CO2. The other cause consists in the depassivation that occurs when the chloride content on the level of the armature exceeds a threshold. It is recognized that this threshold corresponds to a content of 0.4% compared to the mass of cement. [4]

c) Reinforcement corrosion

When a metal is immersed in an electrolyte solution, the metal ions go into the solution, giving a negative charge to the metal. Two dissimilar metals immersed in the same solution will have a different potential and when connecting the two metals through a conductor, the electrons will move the metal which has the most negative potential (the anode) to the metal which has the least negative potential (cathode). So, we will achieve an electrolytic cell. A potential difference may also appear if one metal is used for two electrodes positioned in diverse electrolytes; this is called a concentration cell.

In the case of the steel of the armature, the electrolyte is in the porous structure of concrete and its composition may vary along the armature, resulting in the appearance of cells between the points at diverse potentials.

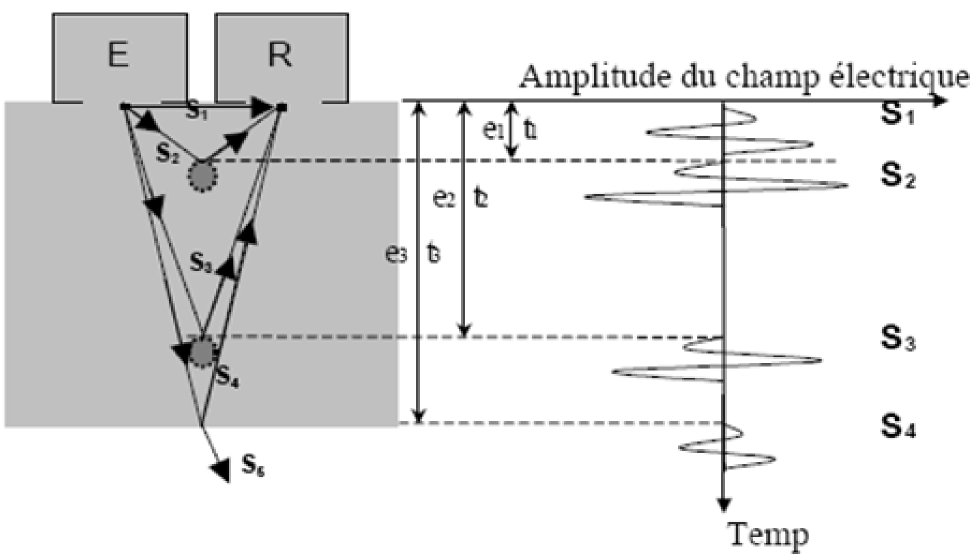


Picture 2 : Schematic representation of the electrolytic corrosion reaction.

III. General Principle of Technology Radar gpr and the Notions about the Electromagnetic Properties of a Environnement with Losses

Many authors reported the principle of radar auscultation in civil engineering
[9]; here, it is only about a fast description of the simplified principle of the structures auscultations of reinforced concrete by pulse radar coupled with antennas. This is a radar brand GSSI, model SIR 2000, using coupled antennas with central frequency about 1.5 GHz (GSSI 5100). A radar permits to send an electromagnetic pulse that will propagate by attenuating more or less in the auscultated environment. The Interfaces present contrast of electromagnetic properties reflects some of the energy emitted by the source. These manifestations are recorded by the receiver during a time interval predetermined by the operator and constitute a radar gram showing the signal amplitude received according the time. Picture 3 shows the type of radar gram that can be suggested to obtain a reinforced concrete slab with two beds of radar reinforcements according a bistatic mode by coupled antennas. In this example, the energy radiated by the antenna which is the "source signal" or "incident signal" is spreading in all directions of the half-space embodied by the air / concrete below the transmitter antenna (E).

A part of the incident signal is transmitted directly to the receiving antenna (R), the signal S1 which is the direct wave transceiver. Part of the radiated energy will be reflected on the armatures of the 1st and 2nd bed, which constitutes the signals S2 and S3 and so on for the following interfaces. Generally the antenna is moved over a linear profile and the radar grams are recorded following a centimetric step. These Radar grams are then processed by thresholding and are shown in grayscale or color. Their juxtaposition allows obtaining a two-dimensional image of the auscultated armature called "cut time", conventionally used for labeling the armatures.



Picture 3 : Schematic diagram of the radar auscultation on a reinforced concrete slab

The response of a non-magnetic material such as the concrete to an electromagnetic excitation is based on two parameters, the electric conductivity; s [S / m] associated with conduction currents and the dielectric permittivity, e [F / m] relative to the polarization phenomena. The concrete is not a perfect dielectric but a material of lost, its permittivity becomes a complex quantity that the imaginary part resulting losses. In addition, as the conductivity of the concrete is not zero, applying a variable electric field generates thus conduction current and a displacement current. The dielectric loss mentioned above, are therefore added ohmic losses by Joule effect. It is impossible, in the frequency range studied by radar technique (300MHz-2GHz), to distinguish the respective contributions of conduction and polarization phenomena.

We then define a relative effective permittivity (er) which is a complex combination of the permittivity and conductivity and allows to treat the material as a dielectric with a complex effective permittivity, the conductivity of the material being then taken into

$$\varepsilon_r = \frac{1}{\varepsilon_0}\left(\varepsilon + \frac{\sigma}{i\omega}\right) = \varepsilon_r' - i\varepsilon_r''$$

account by the imaginary permittivity part (Equation 4).

With ε_0 the dielectric permittivity of the void e0= 8.854.10-12 [F / m]

Where ε_r' and ε_r'' are the real and imaginary parts of ε_r and are respectively called dielectric constant and loss factor.

IV. Experimental Site

Within the structure and Rehabilitation Laboratory was realized a research program to evaluate the effectiveness of the radar technique to control the quality of concrete of reinforced concrete.

For this purpose several samples of concrete dosed at 350 kg / m3 with different depths of water infiltration and chloride ions were made and conserved in the laboratory,

Piture 4 : Auscultation of reinforced concrete panels by GPR technology

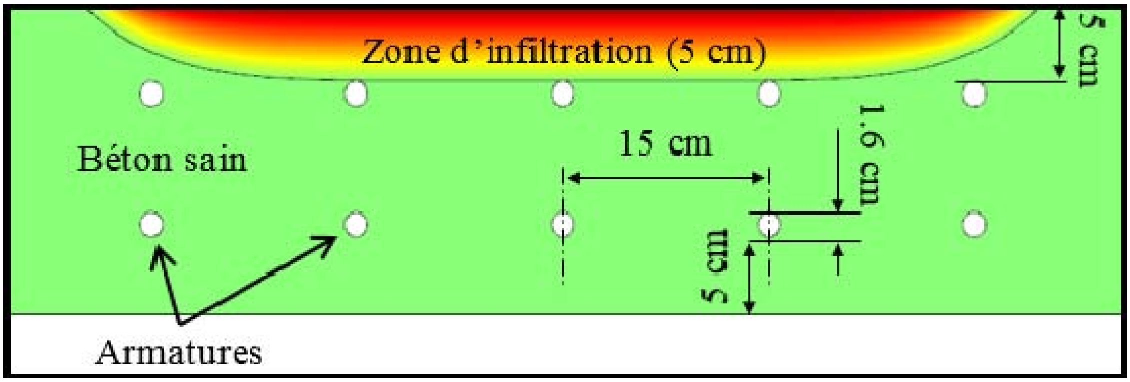
V. Simulation of Electromagnetic Waves Propagation in Concrete

If we assume that the electromagnetic waves propagation in the concrete can be likened to the propagation of a progressive monochromatic plane wave propagating in a specified direction, we show that the dielectric constant affects only the speed of propagation and that the attenuation is primarily due to loss factor. One goal of the development of a simulation tool is to verify these strong assumptions. For this, we suggested a numerical model of the radar antenna used, based on the finite difference temporal domain (FDTD) [6-8]. Through adequate modelized auscultating material, the simulation code allowed us to better understand the radiation of the antenna during its coupling with different materials and verify the two previous hypotheses on all the analyzed signals (direct or reflected). This code has also enabled to better analyze the propagation mode of the direct signal and show that it is divided into two signals; a first is propagating in air and a second propagating in the material. Finally we were able to highlight the impact of the dielectric constant of the coupling material in the shape of the radiation pattern.

VI. Application to the Infiltration of Water and Chloride ion in Concrete Slabs

a) Simulation models

This work intends to study the effect of water and chloride ions infiltration in a reinforced concrete slab on the propagation of GPR waves. For this, we proceed to the simulation of reinforced concrete models infiltrated with solution at different depths from the surface. The model represents a reinforced concrete slab 30 cm thick. Two rows of armatures are also introduced to the interior of the slab. The geometry of the model is shown in Picture 5 below.



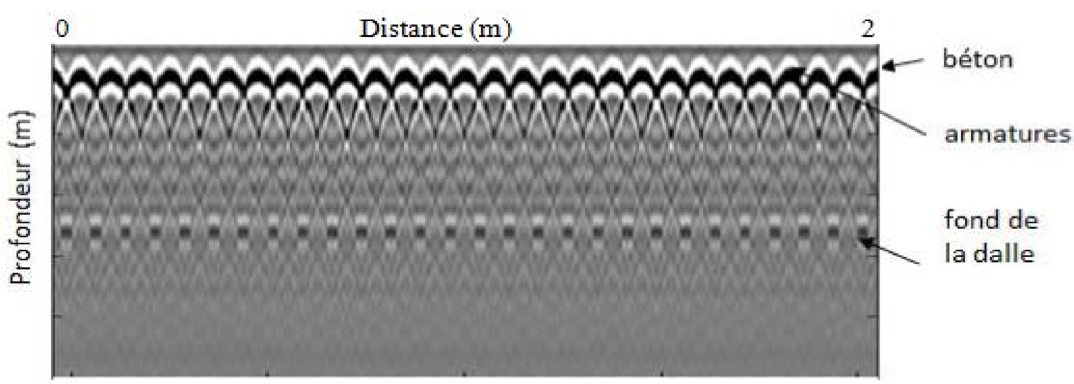
Picture 5 : Illustration of model infiltration to 5 cm deep

For this work, five different models are simulated corresponding to depths of infiltration of 2.5 cm, 5 cm, 10 cm, 15 cm and 20 cm from the surface, in addition to a referential model representing a slab without infiltration .

The infiltration area is characterized by a high permittivity by ensuring the transition with sound concrete and this on a thickness of 5 cm when there is saturation [6]. The permittivity ε and the conductivity of the concrete in normal and saturated state are deduced from the literature [7,8]. We imposed, for a frequency of 2 GHz, worth $\varepsilon^* = \sigma = 11$ and 400 mS/m at saturation and $\varepsilon^* = 5$ and $\sigma = 100$ mS/m for a sound concrete [7] The geometry of the infiltrated volume is designed as respecting the condition of penetration equal depth to the source surface. This penetration provides a transition to the healthy properties of concrete and extends over a maximum thickness of 5 cm when there is saturation at the surface. In this case, when the total depth of penetration is greater than the maximum thickness transition (5 cm), a saturation volume appears on a further depth.

b) Simulation results

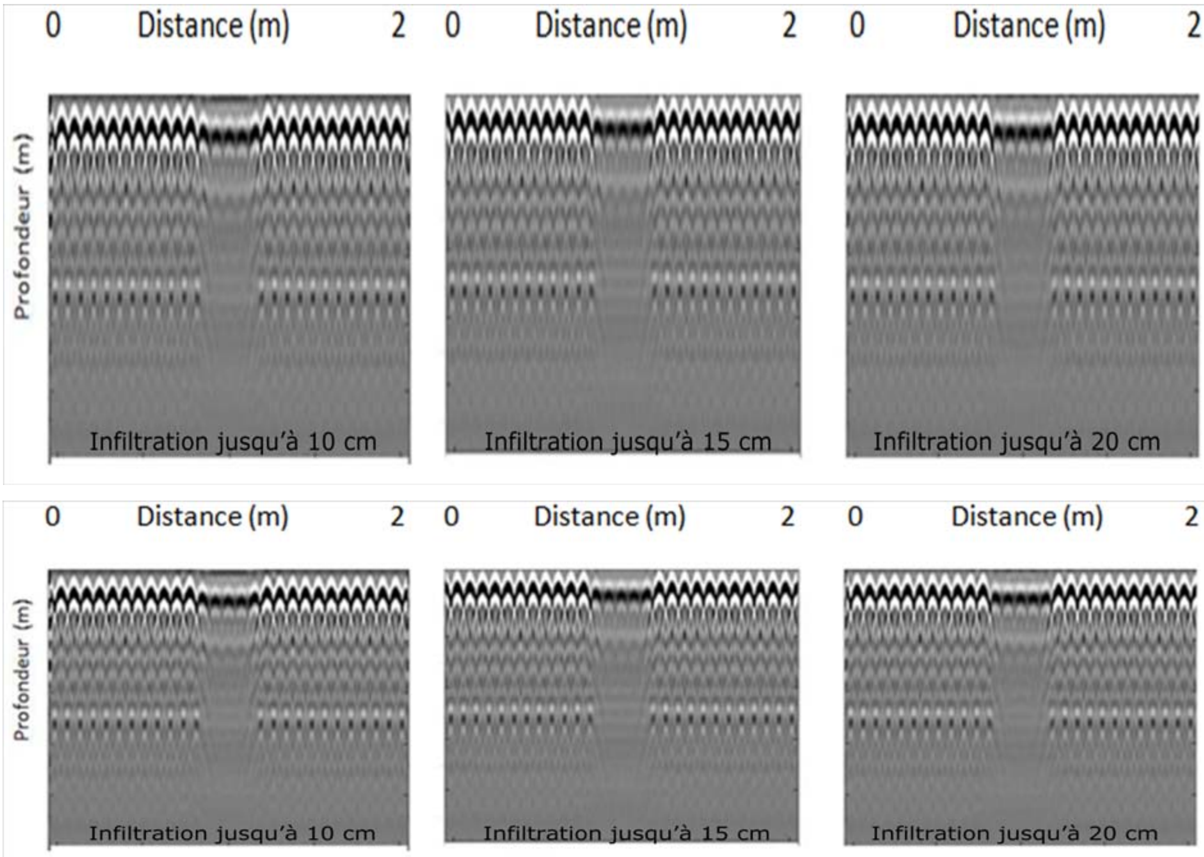
The picture 6 shows the radar gram corresponding to the referential model (hardened concrete). We distinguished the reflection at the concrete surface, superior armature and reflection on the bottom of the slab. Reflections on the lower plates are not visible because they are hidden here by the upper frames.



Picture 6 : radar gram corresponding to the reference model

The reflections presented below appear clearly affected by the infiltration of the water and the chloride ions in the concrete, especially from 5 cm deep. Indeed, as the infiltration area is characterized by higher permittivity and conductivity, it transmits more delayed and attenuated reflections. This is found either on the reflections on the 5 central armatures covered by the infiltrated area on reflections or on the reflections the base of the flagstone.

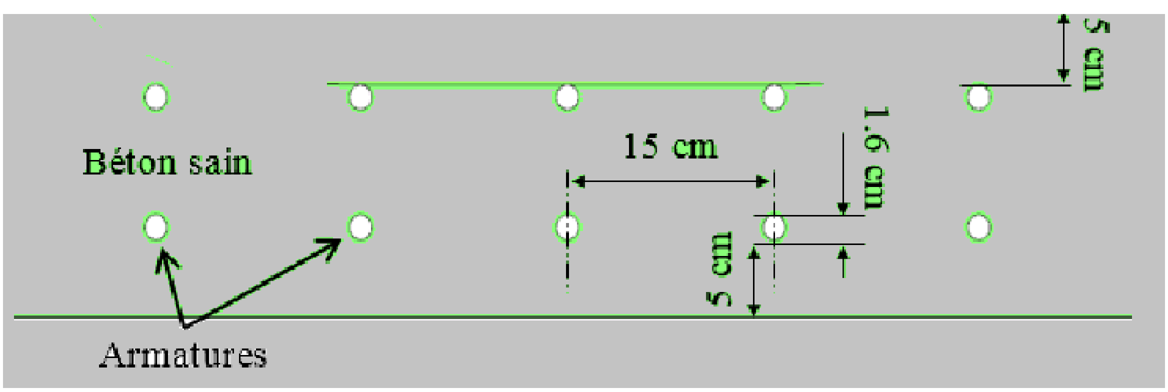
This effect on the reflections affects only the echoes of the targets located in the infiltration. This clearly appears on the radar grams for different depths where there is the echo from the base of the slab is more weakened when the infiltration is deeper, whereas the echo armature remains unaffected from 10 cm depth. These results specify that the reflection of GPR waves on the flagstone base is more sensitive to the infiltration of water and chloride ions in the slabs. This can be explained by the fact that the wave is affected by the properties of the concrete with a thickness about 30 cm compared to a concrete cover of 5 cm of thickness.



Picture 7 : Results of numerical simulations of the infiltration

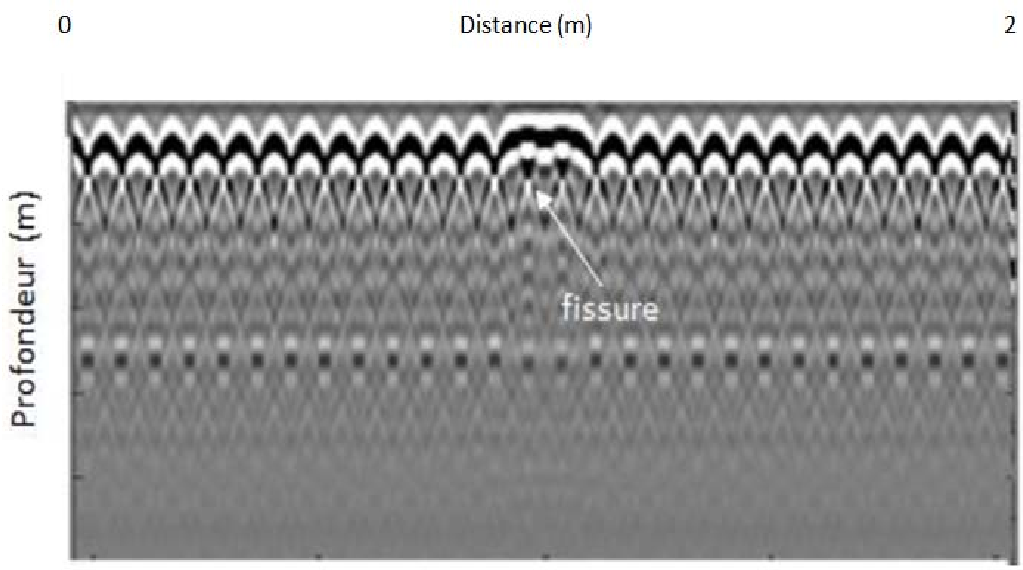
VII. Simulation of a Delamination

The delamination in the concrete is one of the most frequently encountered anomalies that appear mostly in the upper armatures. In order to predict its detectability, a fissure is introduced into a model of sound reinforced concrete (without infiltration of water nor chloride ions). The fissure has an aperture of 0.5 mm, a length of 300 mm and contains water with a salinity of 15 ppm, which is reflected in the model by a complex permittivity medium.



Picture 8 : Model of fissure in reinforced concrete

The radar gram related to this model of delamination (Picture 9) reveals a clear reflection corresponding to the fissure between the three central armatures. The fissure effect results in a significant distortion of the image of the armature. These armatures appear indeed as defined hyperbole when they are in a healthy non-delaminated concrete. Moreover, this reflection does not mask echoes from lower targets (bottom of the slab). In other words, the presence of this delamination is not a great effect on the intensity of the reflection on the bottom of the slab. As a result, in this case, the analysis of the waves reflection on the armatures and informative on delamination of the concrete in the upper armatures than the analysis of more reflection on the bottom of the tiles.



Picture 9 : Result of simulation at 2 GHz in a reinforced concrete

VIII. Conclusions

The Numerical simulations of the propagation of GPR waves in this article indicate that they allow to clearly detecting the deterioration of concrete by water and chloride ions leakage and by the delamination. It has been also demonstrated by the simulations that the reflection of GPR waves on the bottom flagstone is more sensitive to the infiltration of water and chloride ions in the concrete than the reflection on the armatures. Similarly, it has been proved that the detection of the delaminating of the concrete at the top row is easier whereas the wave reflection at the upper armatures rather than the reflection on the bottom of the slab.

The numerical simulation of the wave's propagation phenomena in building materials is therefore useful for the prediction of the test results to optimize the test conditions, to help in the interpretation of statements and for the development of new testing procedures.

IX. Acknowledgement

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Aggregate Angularity on the Permanent Deformation Zones of Hot Mix Asphalt

By Lee P. Leon & Raymond Charles
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Abstract- This paper presents a method of evaluating the effect of aggregate angularity on hot mix asphalt (HMA) properties and its relationship to the Permanent Deformation resistance. The research concluded that aggregate particle angularity had a significant effect on the Permanent Deformation performance, and also that with an increase in coarse aggregate angularity there was an increase in the resistance of mixes to Permanent Deformation. A comparison between the measured data and predictive data of permanent deformation predictive models showed the limits of existing prediction models. The numerical analysis described the permanent deformation zones and concluded that angularity has an effect of the onset of these zones. Prediction of permanent deformation help road agencies and by extension economists and engineers determine the best approach for maintenance, rehabilitation, and new construction works of the road infrastructure.

Keywords: aggregate angularity, asphalt concrete, permanent deformation, rutting prediction.

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Aggregate Angularity on the Permanent Deformation Zones of Hot Mix Asphalt

Lee P. Leon [α] & Raymond Charles [σ]

Abstract- This paper presents a method of evaluating the effect of aggregate angularity on hot mix asphalt (HMA) properties and its relationship to the Permanent Deformation resistance. The research concluded that aggregate particle angularity had a significant effect on the Permanent Deformation performance, and also that with an increase in coarse aggregate angularity there was an increase in the resistance of mixes to Permanent Deformation. A comparison between the measured data and predictive data of permanent deformation predictive models showed the limits of existing prediction models. The numerical analysis described the permanent deformation zones and concluded that angularity has an effect of the onset of these zones. Prediction of permanent deformation help road agencies and by extension economists and engineers determine the best approach for maintenance, rehabilitation, and new construction works of the road infrastructure.

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I. Introduction

The nature of construction materials makes it impossible to design a road pavement which does not deteriorate in some way with time and traffic; hence the aim of accurate structural pavement design is to limit the level of distress. An asphaltic concrete mixture is comprised of 90% aggregate. The other 10% are the air voids and binder content[1]. From these ratios aggregate has a significant role in controlling rutting.

The research focused on the aggregate coarse particle angularity which is defined within the imaging system analysis as being variations at corners, that is; variations superimposed in the aggregate shape[2].

Since the 50's, several methods have been proposed to quantify the form, angularity, and surface texture of aggregate particles[3]. These standardized test methods do not classify all aspect of the aggregate shape. However some researchers have found significant disadvantages of using this test in particle classification [3], [4], [5]. The measurement and classification of angularity is a phenomenon being examined in the last decade by automated imaging systems. Aggregate Imaging System (AIMS) characterizes the shape of fine and coarse aggregates.

It has the ability to analyse the angularity of fine and coarse aggregates[6]. Interesting correlations have been found between aggregate angularity quantified by AIMS and mixture performance [2].

There are many factors that determine the behaviour or performance of a flexible road pavement. One of these performance indicators is the rutting in asphalt-concrete pavements. Permanent Deformation or rutting is caused by the densification and movement of materials under repeated loads, and also might result from lateral plastic flow under the wheel track[7], [8]. It is also described as a pavement condition indicator defined as a 10 mm rut or the first appearance of wheel track cracking. This distress occurs primarily by shear failure in HMA[9].

The properties of coarse aggregate materials (physical shape) significantly affect both the strength and stability of asphalt mixes. In an evaluation of the influence of coarse aggregate shape on the strength of asphalt concrete mixtures, it was concluded that cubical particles possessed the best rutting resistance compared to the other shapes[10]. This means that coarser and high angular aggregates are expected to perform better than low angular aggregate and by extension the finer gradation mixes.

The proper selection of materials is one of the most important tasks in developing an asphalt mixture that shows improved resistance to permanent deformation[11]. Different types of aggregate such as limestone, basalt, dolomite, gravel, granite and traprock have been used for production of asphalt concrete. The high stability has been achieved in using limestone aggregate as compared to basalt aggregate[12].

The prediction of permanent deformation is a complex problem, requiring detailed knowledge of materials state, elastic and plastic deformability and viscosity of pavement materials. As depicted in Fig. 1, there are three distinct stages in the relationship between load repetitions and permanent deformation, which were primary, secondary and tertiary stages. It was also reported that of the design models only the initial and secondary permanent deformation stages are used for predictions[13].

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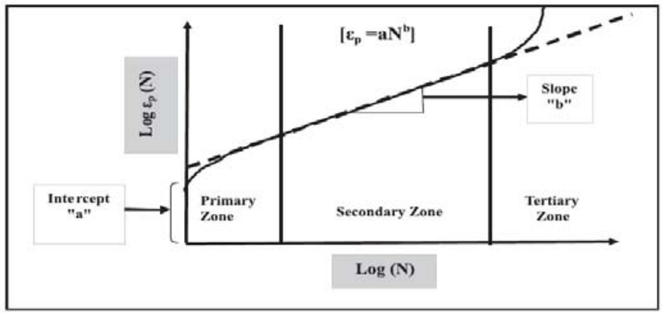

Fig. 1 : Relationships between load repetition and strain [14]

Within this study the first two stages of Permanent Deformation (Primary and Secondary) were examined. A large number of different permanent deformation models such as MEPDG, NCHRP 1-40B and VESYS are already available, but given the same input data, they produce different output (predictions). It is important that these models are easily adjustable in accordance to available historical data and the engineer's knowledge of local materials and environmental effects. The available permanent deformation prediction models have several limitations in that most of them involve large simplifications (e.g. in material behaviour), some of them contain input factors that are difficult to quantify and most are not comprehensive enough (does not consider all influencing factors).

Regarding rutting prediction models found in the Mechanistic Empirical Pavement Design Guide (MEPDG) and by extension National Cooperative Highway Research Program (NCHRP) 1-40B, has specific parameters and do not need to run laboratory testing. It is worth noting that not requiring laboratory testing is both advantageous and disadvantageous, because while it makes the models simple to implement, not using laboratory characterizations of HMA mixes may lead to inaccurate rutting prediction. This research study provides evidence of the variability of the predictions between existing models, as well as a comparison between existing models predictive data and this study data (with the adjustment of aggregate angularity property).

In spite of an enormous effort that has been made in the pavement engineering field, it still is not possible to make accurate and precise prediction of pavement life. Preservation of road infrastructure asset requires a systematic approach such as performance modelling to help in the development of tactical and strategic plans. Pavement performance predictive models allow the forward prediction of future condition based on present condition under a defined range of scenarios[15].

II. Materials and Tests Methods

a) *Material*

Natural Quartzite and Crushed Limestone were the two types of aggregate used in this study. The aggregates produced their respective gradations as shown in Table I. The mixes are dense graded mixes; however they were classified under three categories which were governed by coarse aggregate angularity within the mix (low, medium and high angularity). Trinidad Lake Asphalt (TLA) was the study binder. Aggregate abrasion test evaluated the wear potential of each type of aggregate.

b) *AIMS Imaging System Test*

Aggregate Imaging System (AIMS) was used for imaging analysis to characterize the angularity characteristics of coarse aggregate particles. The test samples were prepared with varying coarse aggregate angularity properties such as low, medium and high. The classification properties of both quartzite and limestone coarse aggregate particles for the mixes and also the identification of the angularity designations are shown in Table I.

Table 1 : Properties Of Coarse Aggregate Materials

Aggregate Type	Abrasion (wear %)	Coarse to Fine Ratio	Angularity ID	AIMS Aggregate Angularity Number	MIX ID
Quartzite (Q)	44%	46% to 54%	Low	<2999	QL
			Medium	3000–5999	QM
			High	>6000	QH
Limestone (L)	30.5%	48% to 52%	Low	<2999	LL
			Medium	3000–5999	LM
			High	>6000	LH

c) Mix Design and Performance Test

All mixes met the road agency standards of acceptable limits of mix properties. The blend of aggregates for both material types used in the various mixes had no statistical significant difference between the two gradations ($p=0.929>0.05$ mean; $p=0.937>0.05$ standard deviation); therefore the research aim of aggregate type effect was accurately examined.

Permanent Deformation resistance of the mixes was evaluated using the procedure of the repeated loading dynamic creep test. The applied test stress was 200 kPa. The testing cycle stops after 3,000 loading applications. The equilibrium test temperature was 35°C.

III. Results and Analysis

a) Aggregate Angularity on Permanent Deformation

The results obtained from the dynamic creep test as shown inFig.2 and Fig. 3 shows that all the mixes whether or not the aggregate type or coarse angularitychanges it still exhibited the theoretical behaviour mentioned by [13]. However the tertiary stage was not evident in the measured or predictive results of the research. Mixtures with aggregates that have low resistance to wear (quartzite) have very low resistance to permanent deformation as compared to limestone material which has a high wear resistance. Even if the mixes were of different categories of angularity (low, medium, high) the results showed that the type of aggregate significantly affects the resistance to permanent deformation.

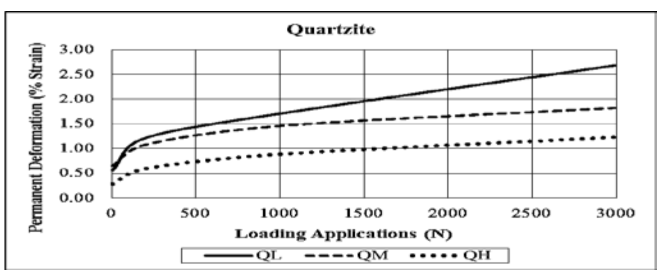

Fig. 2 : Quartzite aggregate angularity on permanent deformation

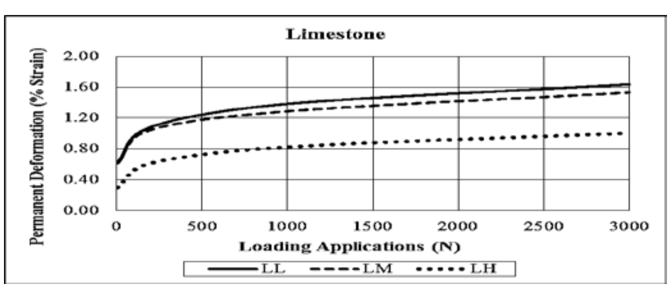

Fig. 3 : Limestone aggregate angularity on permanent deformation

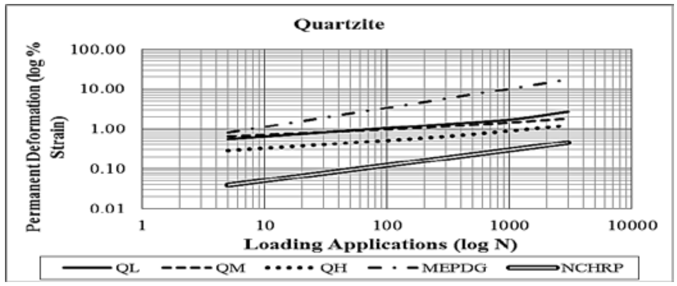

Fig. 4 : Quartzite predictive and measured permanent deformation

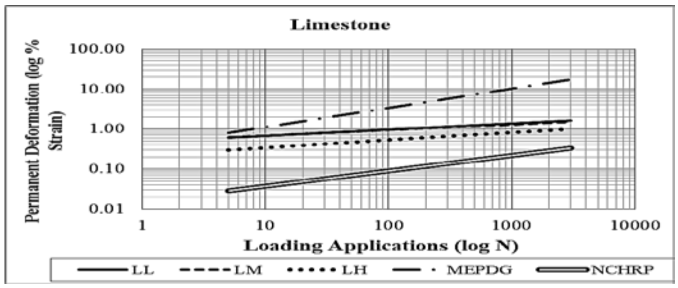

Fig. 5 : Limestone predictive and measured permanent deformation

b) Aggregate Deformation Prediction and Measured Data

The results in Fig. 4 and Fig. 5 shows that the high angular aggregates have higher resistance to rutting, unlike medium and low which has almost the same measured values with each other. As the angularity of coarse aggregate changes to be more angular, the internal resistance increases and the HMA mix improves its capability of carrying traffic load. The high angularity particles possess the highest deformation resistance, followed by medium and low angular particles. It appears that an HMA mix can be made more stable and resistant to deformation by specifying the coarse aggregate angularity.Fig.3also shows a comparison of the results of two permanent deformation prediction models when compared with the actual measured laboratory results. Although the NCHRP model has a model input for angularity (F_{index} and C_{index}), the model still underestimates the percentage of deformation in an HMA mix while the MEPDG overestimates deformation when compared to the measured values. This could be that these models lack a more rigorous variable which accounts for the potential aggregate particle angularity.

c) Permanent Deformation Zones

As shown in Fig. 1 the various zones of permanent deformation versus loading application can be modelled. Refer to (1), (2) and (3) which gives the mathematical explanation of the permanent deformation zones as previously mentioned.

Primary Zone:

$$\varepsilon_p = aN^b \quad (1)$$

Secondary Zone:

$$\varepsilon_p = dN + c \quad (2)$$

Tertiary Zone:

$$\varepsilon_p = fe^{gN} \quad (3)$$

Each equation parameters (a,b,c,d,f, and g) can be determined by regression analysis once the strain and load application cycle are known.

To determine the start of the secondary zone the use of numerical analysis can be employed. This paper employs the Newton-Raphson method, which is an iterative numerical method for finding the solution or roots of equations arising from differential equations. The Newton-Raphson method is based on the idea of linear approximation where the function must be differentiable. As mentioned previously the zones of permanent deformation can be represented mathematically, therefore using the combined (1) and (2) for secondary zone initial transition point, the algorithm developed. A concise explanation of the Newton-Raphson method used in this work is described in (4).

$$N_{n+1} = N_n - \left[\frac{aN^b - dN - c}{abN^{b-1} - d}\right] \quad (4)$$

Using an initial guess of 5 (N value), the following Table II shows results of aggregate type, the minimum and maximum strain and loading application of the transition point.The result in Table II shows that as coarse aggregate angularity increases so does the onset of the secondary stage. It also indicates a lower permanent deformation strain estimate for high angularity.

Various models such as the VESYS rutting prediction model, use the strain estimate at the 200th cycle to predict deformation depth with a pavement structure. However from the research algorithm the VESYS assumption can be affected by the type or abrasion property of the aggregate. Limestone which has a higher resistant to abrasion as compared to quartzite, has the 200th loading application cycle occurring in the primary zone while for quartzite it occurred in the secondary zone.

Table 2 : Transition Points Between Primary And Secondary Zone

Aggregate Type	Angularity #	Load Application, N_{sec}	Strain, $\varepsilon_{p,sec}$	Strain @ 200^{th} cycle, $\varepsilon_{p,200th}$
Quartzite	2019 (low)	105.6	1.0818	1.1397
	6176 (high)	113.4	0.5371	0.5607
Limestone	2770 (low)	327.1	1.1712	1.0853
	6117 (high)	477.7	0.5417	0.4337

IV. Conclusions

If an asphalt mixture deforms (ruts), it is normally because the mixture has insufficient shear strength to support the stresses to which it is subjected to. Aggregates are responsible for minimizing shear failure within an asphalt concrete mix. From the experimental study conducted it can be concluded that the aggregate resistance to degradation (abrasion wearing) is significantly influenced by the aggregate type and by extension its morphological properties. HMA mix density and stability properties can be vastly affected by the aggregate type abrasion wear potential. The higher the abrasion wear resistance, the higher the mix density and greater stability properties when used within a mix.

The AIMS imaging system was shown to be a useful tool for quantifying the angularity characteristics of coarse aggregate. It quantifies the angularity as well as other shape properties for each individual particle within. The analysis of the angularity data is not subjected to human error which leads to more accurate results. For any given type of aggregate, an increase in the coarse aggregate particle angularity in a mix decreases its susceptibility to permanent deformation, while increasing stability potential.

The proposed algorithm for the estimates of onset of the secondary zone was used for different aggregate type with varying levels of coarse aggregate angularity. The existing predictive models did not accurately predict deformation of the mixes because the material properties input are subjected to a user bias test. The research procedure validate that the transition points of permanent deformation zone can be estimated using mathematical models that describe each zones.

The accuracy in the prediction of HMA mixes to permanent deformation can be obtained if prediction models take into account a more accurate or an additional variable for the aggregate particle angularity property.

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Effect of Temperature Variation and Type of Embankment Soil on Integral Abutment Bridges in Sudan

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Eltayeb Hassan Onsa [α], Anwar Adam Ahmed [σ] & Ahmed Gasim Mahmoud [ρ]

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IABs or jointless bridges have many advantages over full height abutment. They eliminate expansion joints in bridge superstructures and simplify design, detailing, and construction. Despite the recognized benefits, the behavior of such structures is not yet fully understood, and nationally adopted design criteria are still lacking.

This paper presents results of finite element analysis of four IABs at Kassala State, the four bridges are considered one of the first fully integral bridges designed and constructed in Sudan. The structural system adopted for these bridges is: RC walls on single row of piles at abutments and piers; hollow-core RC slab at deck. The temperature change is varied between 10°C and 50°C and three types of locally available soil are applied behind the abutments. The effects of varying temperature and embankment soil type in the deflection, maximum bending moments, and maximum shear forces are presented and discussed.

The effect of temperature change and bridge length in the bridge forces is also presented; useful comments on the optimum IAB length to be locally adopted are suggested.

Keywords: integral abutment bridges, jointless bridges, semi-integral bridge, temperature variation, embankment soil, bridge total length.

I. Introduction

Integral Abutment Bridges (IABs) possess a number of unique design details that make them desirable in many applications. These bridges are constructed without expansion joints, within the superstructure of the bridge, nor elastomeric bearings at the supports, i.e. the superstructure is constructed integrally with the abutments and piers [13, 16].

IABs eliminate the use of move-able joints and the expensive maintenance or replacement costs that go with them. The overall design of IABs is simpler than that of their non-integral counterparts; the simplicity of these bridges allows for rapid construction. IABs have proven themselves in earthquakes and performance studies. The advantages of IABs make them the preferred choice for many design and construction engineers in Sudan and worldwide.

Despite the significant advantages of integral bridges, there are some problems and uncertainties associated with them. These include the following, [10]:

- Temperature-induced movements of the abutment cause settlement of the approach fill, resulting in a void near the abutment if the bridge has approach slabs.
- Secondary forces (due to shrinkage, creep, settlement, temperature and earth pressure) can cause cracks in concrete bridge abutments.This problem can be eliminated by using approach slabs.

a) Soil – structure interaction at IAB embankments

Although the IAB concept has proven to be economical in initial construction for a wide range of span lengths as well as technically successful in eliminating expansion joint/bearing problems, but is not problem-free overall in service. Because of the increased use of IABs, there is now greater awareness of and interest in their post-construction, in-service problems. Because of the continuity between superstructure and substructure of IABs, there is a significant interaction with surrounding soil and backfill behind abutments, especially during thermal expansion as the structure is pushed into the soil of the backfill, see Figure 1. The soil is usually represented as an elastic-plastic material whose properties affect internal forces in the integral bridge, [8, 10, 12]. Therefore, it is necessary to consider the influence of embankment soil in the integral bridge design. This is,apparently, seems one of the main problems in the analysis of IABs in practice.

Fundamentally, these problems are due to a complex soil-structure interaction mechanism involving relative movement between the bridge abutments and adjacent retained soil. Although such problems turnout to be primarily geotechnical in their cause, they can result in significant damage to structural components of the bridge. Overall, these post-construction problems,

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and the maintenance and/or remedial costs they generate, inflate the true life-cycle cost of an IAB.

As the bridge superstructure goes through its seasonal length changes, it causes the structurally connected abutments to move away from the soil they retain in the winter and into the soil during the summer. The mode of abutment movement is primarily rotation about their bottom although there is a component of translation (horizontal displacement) as well. The total horizontal displacements are greatest at the top of each abutment

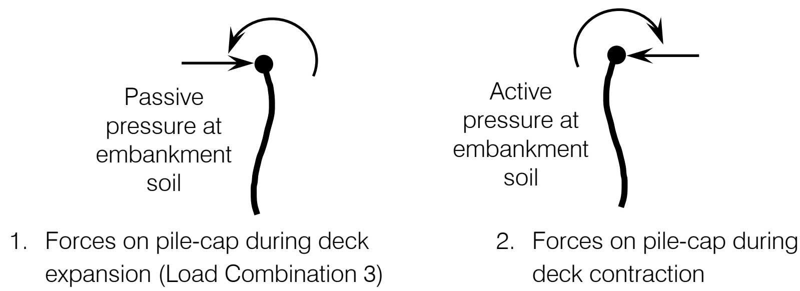

Figure 1 : Abutment piles: deformed shape and forces at pile head

and can have a maximum magnitude of the order of several centimeters [8, 12, 13].

II. Case Study: four IABs in Sudan

Four IABs at Karakon – Hameshkoreib road in Kassala State at east of Sudan are presented in this paper as case study. Table 1 shows the bridges main data and Figures2 to 4 illustrate the general views regarding Bridge #2; the other three bridges differ from Bridge #2 in the number of spans and totallengths.

Studying the effects of longitudinal bridge movement on the forces at the four subject bridges was a major focus of the paper. A bridge will expand and contract from seasonal and diurnal variations in temperature and will contract with concrete creep and shrinkage strains. Piers and abutments must be designed to accommodate this movement, and the superstructure must be capable of carrying the forces induced by the stiffness of the piers and abutments.

Table 1 : Main geometric data of four IABs

Bridge	No. of spans	Span (m)	Width (m)	Total length (m)
Bridge #1	3	17.0	12.0	51.0
Bridge #2	2	16.0	12.0	32.0
Bridge #3	4	17.0	12.0	68.0
Bridge #4	5	17.0	12.0	85.0

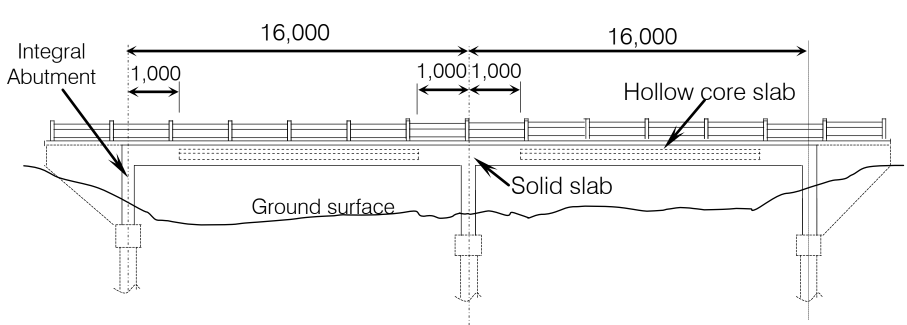

Figure 2 : Elevation at Bridge #2

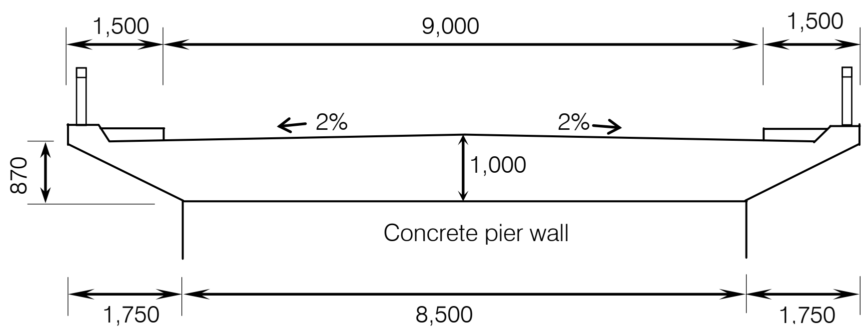

Figure 3 : Cross section at solid part of the deck slab

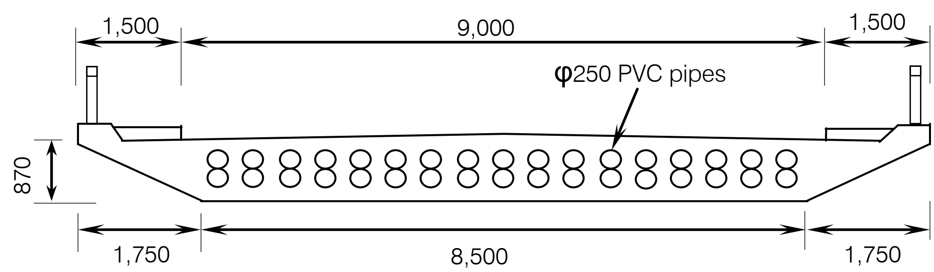

Figure 4 : Cross section at hollow core part of the deck slab

a) Materials and design data

The following sections present the material, geometric and design data adopted for the analysis and design of the four bridges; see also Tables 2 and 3 and Figures 2 to 6.

Table 2 : Abutment properties

Unit	Moment of initial, I (m^4/m)	Modules of elasticity E, (kN/m^2)	Rigidity EI, (kN/m^2)
Abutment wall	0.018	1.40×10^7	2.52×10^5
Pile cap	0.630	1.40×10^7	2.28×10^6
Pile (equivalent for 1m)	0.003	1.40×10^7	2.52×10^4

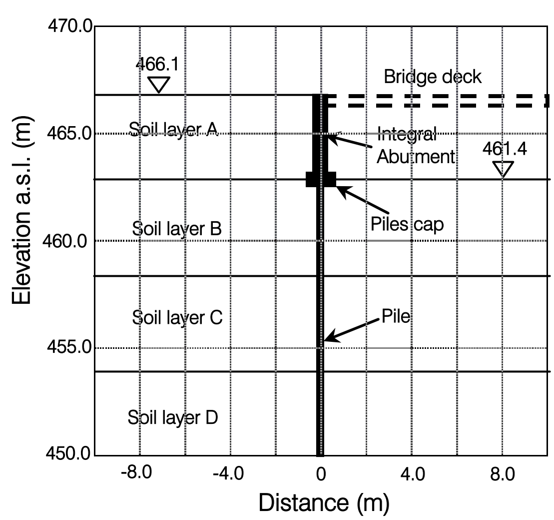

Figure 5 : Soil layers used in the model

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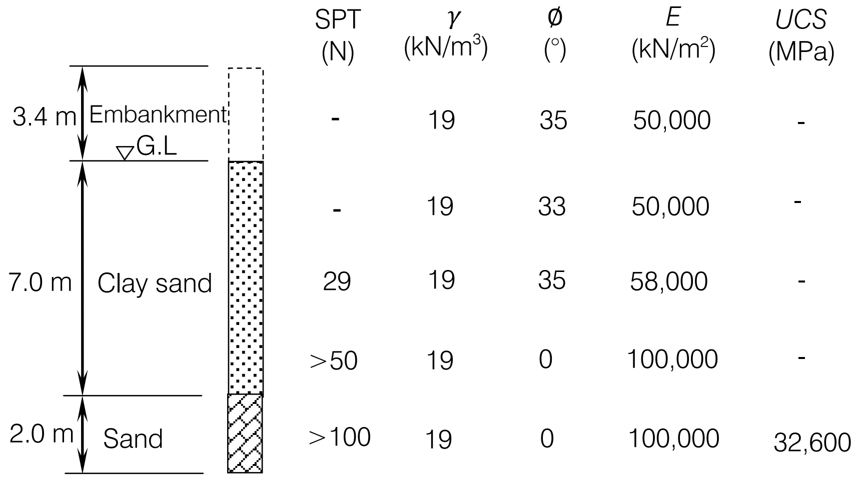

Figure 6 : Soil profile at Bridge # 4

Table 3 : Soil properties

Soil layer	Soil type		Unit weight, γ_s (kN/m³)	Modules of elasticity, *E* (kN/m²)	Angle of friction, ϕ (°)
A	Embankment	soil 1: Fine sand	18.0	40,000	25
		soil 2: Gravely sand	19.0	50,000	35
		soil 3: Gravel	18.0	100,000	0
B	sand		18.0	50,000	25
C	Sandy clay		18.0	58,000	29
D	Sand stone		19.0	100,000	0

Temperature effect is calculated assuming the following:

- Thermal expansion, $\Delta_L = L \times \Delta T \times \alpha$ .... (1)

  Where L = length of the bridge, ΔT = the temperature range between temperature at time of setting of bridge concrete to the maximum and minimum temperature extremes.
- Max. air temperature = 65°C.
- Min. air temperature = 10°C.
- Temperature at time of setting assumed = 25 °C.
- Thermal coefficient of expansion, $\alpha = 12\times10^{-6}$ mm/mm/°C
- The bridge deck Type 3, according to [3].

Effective Temperature Change, ΔT:

The effective temperature is the temperature that governs the overall longitudinal movement of the bridge superstructure. Determination of the effective temperature is a complex problem influenced by shade temperature, solar radiation, wind speed, material properties, surface characteristics and section property [11].

The following equations are sometimes used to calculate the effective temperature change, [4]:

$$\Delta T = T_1 - T_2 + \frac{T_3 - T_1}{3} \quad \text{.....} \quad (2)$$

Where,

T_1 = air temperature at dawn on the hottest day,

T_2 = air temperature at dawn on the coldest day,

T_3 = Maximum air temperature on the hottest day,

However, temperature calculated using Equation 1 does not seem to be suitable for the case of IABs in Sudan since it gives too low temperature changes. Hence, in the absence of approved temperature contours in Sudan, the Authors used maximum and minimum temperatures corresponding to the nearest metrological station at Kassala Town (100km to South from Bridge #2).Calculation of temperature effects are performed using the procedure shown in reference [3].

The effective temperature change also depends on the air temperature at concrete setting: assumed here = 25 °C. However, to illustrate the extended effect of temperature change on the forces exerted on the IABs the temperature change is varied between 10°C and 50°C.

Analysis steps:

Longitudinal capacity:

Calculate the active earth pressure coefficient, K_a needed to resist braking and traction forces, applying $\gamma_m = 0.5$ to K_a Check that sufficient horizontal capacity is available from the earth behind the abutment to resist the longitudinal forces, and check the magnitude of the horizontal movement required to mobilize the required earth pressure.

- Check horizontal movement.
- Check capacity of soil to resist horizontal forces.

Analysis of deck, piers, and abutments:

The whole bridge structure is modeled and all bridge load combinations are applied. Linear elastic foundation model based on actual soil parameters is applied at piles and abutment wall.

The abutment piles are designed such that their diameters are much smaller than abutment wall thickness to insure negligible restraint to rotation (pinned ends) at abutment/pile interface [5, 15]. Hogging due to creep is therefore also unrestrained, but can be ignored. Maximum thermal expansion and Load Combination 3 are applied [1, 2,3] wheremaximum earth pressure on abutment walls is based on lateral earth pressure coefficientK* calculated as if expansion is unrestrained, $K_0 + (d/0.03H)^{0.6}K_p$, where d = longitudinal defection at top of abutment, K_0,K_p = coefficients of at rest and passive earth pressure, respectively,[clause 3.5.5 in [2])

Maximum thermal contraction, together with minimum bridge loads and active earth pressures are applied as loads. The effects of long term creep and positive differential temperature loading are included. Load Combination 3 is applied to deck expansion, considering passive earth pressure and rotation at pile heads, i.e.Piles are designed for bending. Thermal movement, creep rotation and rotation due to differential temperature loads are applied to pile heads, resulting in reverse bending in piles.

b) Results of analysis

The interaction of abutment wall and piles with soil layers are modeled using finite elements concepts. The results of longitudinal defection, bending moment and shear force at abutment/deck joint for the four bridges are presented in Figures 7, 8 and 9, respectively.

It is worthwhile mentioning that for the 4 bridges the negative moment and shear force at abutment governed the design. Design sagging moments within spans and negative moments at piers are governed by Load Combination 3 (permanent loads, primary live loads, and temperature loads)

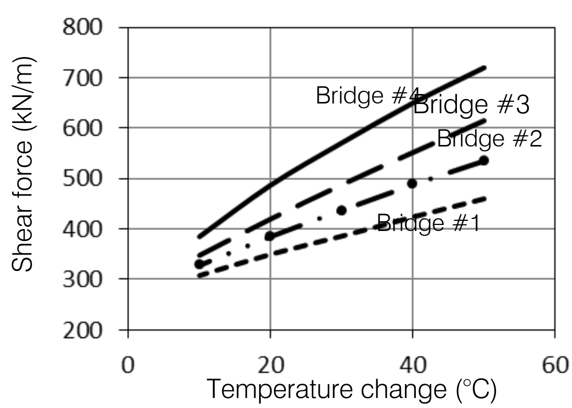

Figure 9 : Effect of temperature change in the shear force at abutment/deck joint

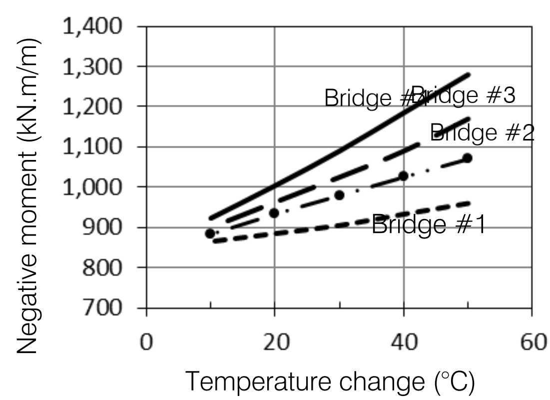

Figure 8 : Effect of temperature change in the moment at abutment/deck joint

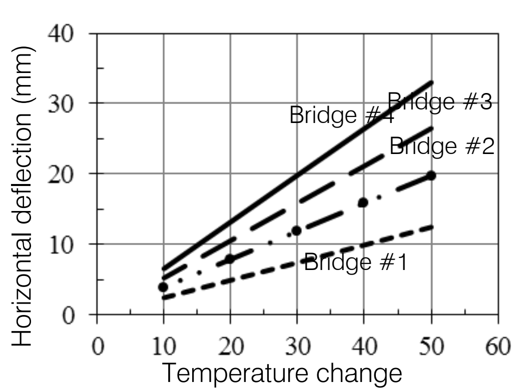

Figure 7 : Effect of temperature change in the horizontal deflection at top of abutment

In this paper three types of soil are tried at embankments behind the abutments, Table 2 shows the physical properties of the three embankment soils.

Effect of temperature and bridge total length:

Although it was advised to adopt IABs up to 60 meters, [2, 8], many countries experiences much longer IABs [10,13]. In this study the longest IAB is 85m long. Also note that 3 of the 4 subject bridges have same span but differ in total length, the effect of temperature change showed 9.6% average increase in negative bending moment, at abutment/deck joint, due to 10°C increase in temperature change e.g. in Bridge #4 (85m long). Figure 10presents the effect of temperature and bridge total length the maximum negative moment at top of abutment walls of the 4 bridges.

It is noticed from Figure 10 that for IABs longer than 65m the forces at abutment/deck slab joint start to increase rapidly at temperature change = 50°C (the temperature change normally experiences in Sudan) resulting in non-economical cross sections; this probably explains the advice of given in [2]. Therefore, it is recommended at present time to adopt alternativebridge setup e.g. for bridges with total length exceeding 100m semi-integral bridges are more appropriate where bridge deck is placed on sliding bearings over the abutment front wall.

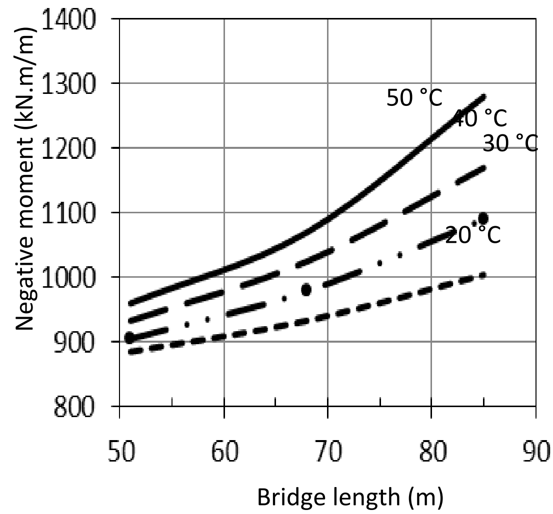

Figure 10 : Effect of temperature and bridge length in the moment at abutment/deck joint

However, the literature review and field inspections indicate that the maximum lengths of integral abutment bridges have not been reached [7, 10]. Jointless bridges over 180 meters in total length have been built and have performed satisfactorily in USA [6].

Table 4 : Analysis results: Effects of embankment soil, Bridge #4, temperature change = 40°C

Type of embankment soil	Analysis Results at Abutment/desk joint		
	Moment (kN.m/m)	Shear (kN/m)	Horizontal deflection (mm)
soil 1: Fine sand	1185	554	26.48
soil 2: Gravely sand	1185	543	26.42
soil 3: Gravel	1185	560	26.45

III. Conclusions

The following conclusions are drawn from this paper:

Changing the soil properties behind the abutment and around the piles does not affect significantly the performance of deck slab in terms of bending moment, shear force and horizontal deflection.

The bending moment, shear force, and deflection in deck slab tend to increase linearly with increase in temperature.

As expected, the variation in soil type at embankment behind the abutment wall has negligible effect in the deformation and forces at wall to deck joint, see Table 4.

The restraint provided by abutment wall backfill is usually considered ineffective in reducing the free thermal expansion of the superstructure this is attributed to the fact that the superstructure to abutment in the direction the bridge is high, and the reactive soil pressure at top of abutment wall is often considered low.

The bending moment and deflection in deck slab increases linearly with increase in temperature.

The internal forces in the abutments are found to be functions of the thermal-induced displacements of the bridge deck, properties of the pile and stiffness of the foundation soil. Similar to conclusion was reported in [9, 14].

For countries experiencing high temperature changes, like Sudan, and until further verifications are reached, the maximum total length of IAB shall be carefully controlled.it is recommended at present time to adopt alternative bridge setup e.g. semi-integral bridges for bridges with total length exceeding 100m.

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Strengthening of the Permeability of Sandy Soil by Different Grouting Materials for Seepage Reduction

By Mohamed A. Abd El-Latief, Mohamed B. Ashour & Ayman C. El-Tahrany

Abstract- Grouting is an effective way to improve the engineering properties of the soil to reduce soil permeability. In this research, an attempt has been made to study on effectiveness of grouting materials on seepage reduction. The purpose of this paper is to focus on the efficiency of current available grouting materials and techniques from construction, environmental and economical point of view. The seepage reduction usually accomplished by either chemical grouting or cementious grouting using ultrafine cement. In addition, the study shows a comparison between using grouting materials according to their degree of permeability reduction and cost. The comparison is made based on achieving a permeability reduction up to 10-7 m/Sec. The application of seepage reduction is based on the permeation grouting using grout curtain installation. The computer program (SEEP/W) is employed to model of dam rested on the sandy soil, using grout curtain to reduce seepage quantity and hydraulic gradient by different grouting materials. This analysis focuses on defining the best material for seepage control from the economical, installation, environmental effect safety interest.

Keywords: *seepage, grouting materials, grout curtain, dam, seep/w.*

GJRE-E Classification : FOR Code: 090503

STRENGTHENINGOFTHEPERMEABILITYOFSANDYSOILBYDIFFERENTGROUTINGMATERIALSFORSEEPAGEREDUCTION

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Strengthening of the Permeability of Sandy Soil by Different Grouting Materials for Seepage Reduction

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Keywords: seepage, grouting materials, grout curtain, dam, SEEP/W

I. Introduction

Grouting is defined as the procedure of filling or injecting fluid with pressure into the soil, generally via boreholes [18]. The purpose of injecting a grout is to decrease permeability of the soil and to increase the shear strength of the foundation soil. Grouting materials used for filling the voids existing in the soil to reduce permeability of soil [4]. Two classes of grouting materials are classified for seepage reduction: i) suspension-type grouts, ii) solutions-type grouts. The suspension-type grouts include clay and cement, while solutions-type grouts include a wide variety of chemicals such as acrylamide, N-Methaloacrylamide, acrylate and colloidal silica [9].

Grouting is a technique to inject various types of grout into the ground at a deliberately controlled pressure and flow rate [10]. The grout is based on cement, silicate, or other materials, selected to suit particular ground conditions and improvement objectives. The grout fills in voids and cracks of the ground and permeates into soil pores to produce a solidified soil-grout mass [2]. The grouting is often applied to reduce permeability of soil underneath existing hydraulic structures, such as dams, regulators and others [4].

Permeation grouting for stabilization of fine sand is the longest-established and the most widely used grouting technique to seepage reduction. It involves the filling of the pore space of soils. The objective is to fill a void space without displacement of the formation or any change in the void configuration or volume [17]. In this paper, a comparison between the grouting materials for seepage reduction is presented and defining the grouting material that is environmentally friendly and more cost-effective.

II. Grouting Material For Seepage Reduction

In order to choose a grout type, several properties of grout should be concerned, such as rheology, setting time, toxicity, strength of grout and grouted soil, stability or permanence of the grout and grouted soil and the penetrability of the grouted soil [12]. Moreover, spreading of the grout plays an important role in the development of grouting technology. In the actual filed, the grouting method requires an extensive consideration on the grout hole equipment, distance between boreholes, length of injection passes, number of grouting phases, grouting pressure and pumping rate [14].

a) *Suspension -Based Fine Grouts*

i. *Cement grout*

In this type of grouting materials, the micro fine cement is used to permeate between the soil particles. It has an average particle size of 3 to 4 microns [3]. The cement grout decreases the permeability about 5 orders of magnitude as the cement - water mix between (0.5 – 5). Cement grouts are the least expensive type, it costs about \$1 to \$2 per liter of mixed grout [5]. The typical published values of permeability are listed in Table (1). The cement grout would cost about \$100 to \$ 200 per cubic meter of treated soil [1].

ii. *Cement- bentonite grout*

In this type of grouting materials, the bentonite is used with the micro fine cement to reduce the cost of

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the grout materials [5]. The permeability of the soil decreases by increasing the percentage of the bentonite [7]. It is a highly porous solid with a low permeability that lies somewhere in the cement and bentonite range, from 1x10-7 to 1x10-11 m/Sec. Typical published values of permeability are listed in Table (1). The cement-bentonite grout decreases the permeability about 3-4 orders of magnitude. The cement- bentonite grout would cost about $65 to $ 75 per cubic meter of treated soil [1].

iii. *Clay (bentonite) grout*

This grout is used to reduce the cost and also is used to reduce the permeability by increasing the percentage of clay [14]. The permeability of the soil is reduced about 3-4 order of the magnitude based on the clay concentration. Typical published values of permeability are listed in Table (1). High – clay grout is mixed into two stages. The first stage includes making a clay water slurry. The second stage of grout includes adding a binder material such as cement. Clay grout would cost about $35 to $ 45 per cubic meter of treated soil [1].

Table 1 : k of grouted soil (suspension grout) [1&4]

Grout Type	Characteristics	k (m/sec)
Neat cement	w/c ratio = 0.5 to 5.0	10^{-7} to 10^{-9}
Cement-bentonite	w : c : b = 4 : 1 : 1	10^{-8} to 10^{-10}
Bentonite slurry	20 % solids	10^{-7} to 10^{-10}

b) *Chemical (Solution Grouts)*

i. *Acrylamide grout*

Grouters inject acrylamide to reduce the permeability. It has a viscosity and density similar to water. Acrylamide is considered to be permeant. The acrylamide grout decreases the permeability about 6-8 orders of magnitude [2]. A minimum of 10 % acrylamide solution is needed to assume a good gel. The World Health Organization considers acrylamide to be a neurotoxin and a potential carcinogen [9]. The cost of acrylamide grout is about $500 per cubic meter of treated grout [1].

ii. *NMA grout*

used to reduce the permeability. N-Methaloacrylamide is not a toxin. So, NMA is better in use than acrylamide grout where drinking water is found. The reduction of permeability is similar to acrylamide about 6-8 orders of magnitude [13]. The cost of N-Methaloarylamide grout is about $550 per cubic meter of treated grout [1].

iii. *Acrylate grout*

In this type of grouting materials, the acrylate grout is used to reduce the permeability of soil. Acrylate gel is used as a less toxic material. It has a high viscosity. Turner 1998 reported the acrylate grout reduce the permeability about 1-3 orders of magnitude [14]. The acrylate grout would cost about $325 per cubic meter of treated soil [1].

c) *Colloidal silica grout (CSG)*

comprises a mixture of sodium silicate and reagent solution, which change in viscosity overtime to produce a gel. Reagent solution is organic or inorganic materials [15]. CSG has a low viscosity. Yone-kura and Miwa reported the permeability of the soil is reduced about 4-5 order of the magnitude based on the concentration of colloidal silica [19]. Perself 1997 made tests to determine the hydraulic conductivity of sand grouted by silica gel, it was found the hydraulic conductivity is decreased by increasing concentration of colloidal silica in the grout [11]. Colloidal silica grout would cost about $60 to $ 180 per cubic meter of treated soil [1].

Table 2 : k of grouted soil (chemical grout) [4 &18]

Grout Type	Characteristics	k (m/sec)
Acrylamide grout	Toxic grout	10^{-12}
NMA grout	Non toxic	10^{-12}
Acrylate grout	Less toxic	10^{-5}
Colloidal silica grout	Non toxic	10^{-9} to 10^{-11}

Finally, figure (1) explain the maximum permeability of the soil after injecting by the grouting materials [6].

i. *Grouting Techniques*

The soil improvement techniques are effective for each of the allowed or required disturbance of existing structures. The following methods, which imply a low level of vibration, are useful to improve soil strengthening and reduce the permeability [16]:

- Compacting grouting
- Permeation grouting
- Jet grouting
- Hydro fracture grouting.

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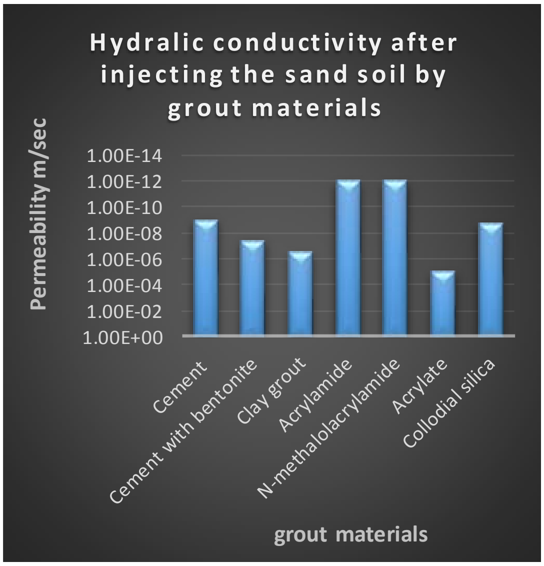


Figure 1 : Maximum Hydraulic conductivity can be achieved after injecting a sand soil by grout materials [6]

ii. *Permeation grouting for seepage reduction*

Permeation grouting includes the injection of a low-viscosity fluid in the soil pores without changes in the soil physical structure. The main goal of permeation grouting is both to strengthen soil and to waterproof ground by filling its pores with injected fluid [17]. This method improves the soil physical and mechanical characteristics, stabilizes the excavation walls in soft soils and controls the groundwater migration [12]. As a results can be implemented the underpinnings beneath the existing foundations. Cementious grouts are generally used for medium to coarse grained sand. Chemical grouts are used in formations with smaller pore spaces, but are limited to soils coarser than fine grained sands. The process of permeation grouting is schematically shown in Figure (2) [18]. The quality control during permeation grouting is very important to ascertain the effectiveness of the technique.

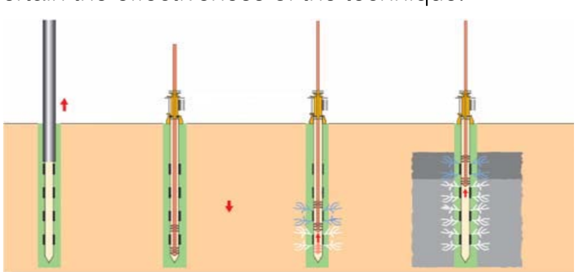


Figure 2 : The process of permeation grouting

iii. *Effect of repeated cyclic loading*

To understand the performance of grouted sand under cyclic loads, a complete record of the changes in the stress strain characteristics is required. The major properties of concern are the variation of cyclic strain and damping ratio with the number of cycles at different stress levels [4]. The grouted area is affected by the repeated cyclic loading based on the grouting material used. The suspension grouting is fragile, on the other hand, the chemical grouting is soft and flexible material. It is here known as the impact of the repeated load on fragile material. The effect of cyclic loading can damage a fragile material, but the soft material can withstand against these load [4].

iv. *Depth of Grout Curtain and Hole Pattern*

The purpose of curtain grouting is water seepage control, the grout holes are arranged in a series of rows to form a curtain approximately perpendicular to the direction of seepage [18]. The depth of the holes is dependent on design considerations as well as the depth of the soil and the head at upstream. For permeation grouting 38mm probe diameter is the most common in use. Curtain grouting, which can be single-row or multiple row of curtain. Single-row of curtain grouting is drilled as a widely spaced system of primary holes, subsequently followed by secondary and tertiary holes at a progressively smaller spacing. The initial spacing (of primary holes) usually varies between 6 m to 12 m based on the geological conditions and an experience [8]. The standard positions for grouting curtains are at the upstream of the dam to reduce the seepage and uplift pressure [8].

v. *Grout estimation*

The depth of a curtain is determined by considerations of the seepage characteristics of the foundation. The depth of the curtain is established by empirical procedures. So the depth equal to 0.5 H to 1.5 H or to reach the impervious layer. The hole spacing relates to the grouting rate to be used, the permeability of ground to be treated, and the allowable grouting pressure. There are mainly three different types of grout hole patterns used for grouting works [13]. These types are called the random spacing, the fixed spacing and split spacing. Houlsby (1990) proposed another way to construct the grout curtain figure (3) [8]. It is based on three stages of holes (primary, secondary and tertiary) each of them has a different depth, and if necessary, quaternary and quandary holes can also be drilled. The primary spacing used is 12.0 m in most of cases, but can also be less (6.0 m minimum) to reduce the permeability to satisfactory level [16].

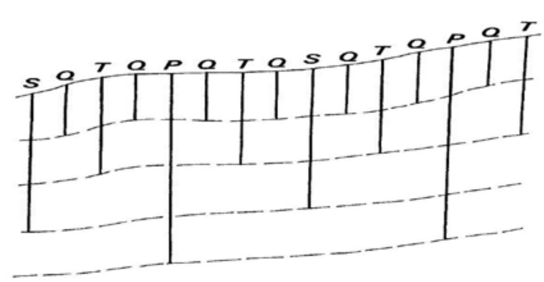


Figure 3 : Design of the grout curtain

vi. *Grout estimation*

The quantity of grout which is used for a particular application depends on the thoroughness required of the work and the volume of the pore void system of that particular soil to be improved. The volume of the voids can vary greatly at a given density, depending on both the shape of the grains and their moisture content [18]. Understanding the soil porosity is a fundamental to determine the amount of grout that will be required to treat a given volume of soil. To make a serious estimation of grouting materials, it requires a geological study to evaluate the void content and the design of the grout curtain [18]. The volume of grouting materials is given by the following formula (Henn 1996) [6].

$$V_g = V_z\,(\eta F)\,(1+L) \qquad (1)$$

Where, V_g = Volume of grout intake, V_Z = Volume of grouted soil, η = Porosity of soil. F = Factor of filling (0.85 to 1.0), L = Loss Factor (0.05 to 0.15). Where, each of grout loss and Void filling factor depend on the properties of the grouted materials. Another method for estimating the quantity of grouting materials depend on the porosity of soil. The expected volume of required material depends on Casagrande formula:

$$K = 1.40\, e^{2}\, K_{0.85} \qquad (2)$$

$$V_g = \eta_{net}\, V_z \qquad (3)$$

Where, K = the permeability of the soil, V_Z = Volume of grouted soil, e = Void ratio, η_{net} = the net porosity of soil.

III. Comparison Between The Grouting Materials For Seepage Reduction

In order to choose the best grout type, several properties of grout should be concerned, such as rheology, setting time, toxicity, strength of grout and grouted soil, stability or permanence of the grout, the penetrability , water tightness of the grouted soil and the cost of each material [12]. Now, the comparison between the grouting materials are used to seepage reduction will be explained based on references and pervious experiments according to Gel time, PH, viscosity, and grouting techniques for seepage reduction Figure (4:7).

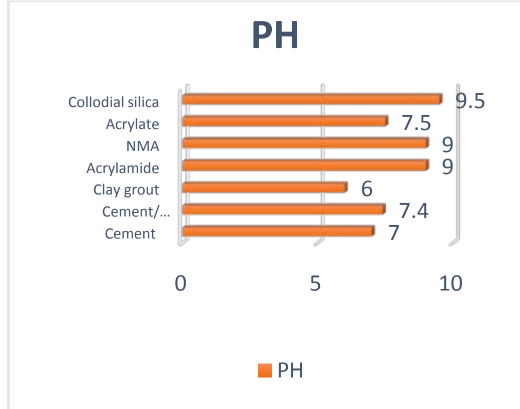


Figure 4 : PH for grouting mix [9]

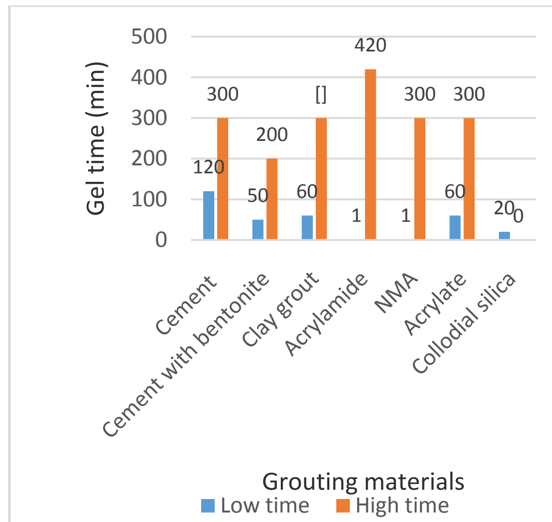


Figure 5 : gel time for grouting mix

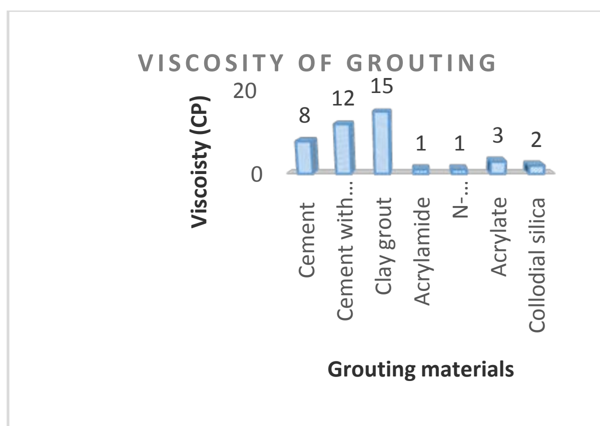


Figure 6 : viscosity of grouting mix

Permeation Grout	Jet Grout
Used for seepage control(cementious & Chemical grout)	Used for strength of soil and seepage control(cementious grout) not used for seepage control
Compaction Grout	**Fracture Grout**
Used for strength of soil but not seepage control (cementious & Chemical grout)	Used for strength of soil but not seepage control (cementious & Chemical grout)

Figure 7 : grouting techniques for seepage control

IV. Estimation of Grouting Materials (Volume & Cost)

a) *Case of Study (Seepage Control under a Dam)*

This case of study as shown in Figure (8), the dam rests on the sandy soil with depth 14.0 m and followed by impervious layer. The dam is 18.0 m long, 18.0 m wide and 1.5m buried from the foundation. 6.0 m the head at upstream of the dam.

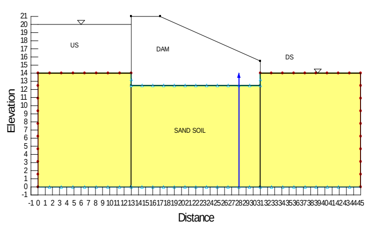


Figure 8 : Geometry Model for 2D SEEP/W Analysis

b) *Grout curtain used in the case of study*

The curtain effectiveness may be increased by using multiple grout lines. In curtain grouting the purpose is impermeance, the grout holes are arranged in a series of lines to form a grout curtain approximately perpendicular to the direction of seepage with length 24.0m at upstream of the dam. In this type of curtains, it is usual to drill a widely spaced system of primary holes, subsequently followed by secondary and tertiary holes at a progressively smaller spacing. The initial spacing of primary holes starting with 6.0 m based on the grouting materials to achieve the best design for seepage reduction. In our case of study, two rows of the grout curtain are used to define the cost of each material based on the quantity of grout injection and installation as shown in figure (9).

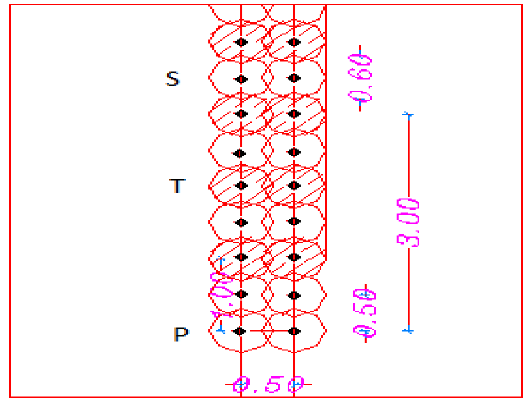


Figure 9 : Layout of holes

c) *Grout quantities*

An initial estimate of the volume of required grout depends on the treated zone and permeability of the soil. The required grout quantities can be twenty percent or more of the total treated zone. This is represented by the mean net grout intake. The expected total grout quantities should be predicted. The target grout volumes should be established and assigned to the primary, secondary, tertiary and quandary grout holes. Larger target quantities are usually specified for the primary and secondary holes, and reduced quantities anticipated for the tertiary and quaternary holes.

d) *Criteria of Grout injection*

The pressure, which is measured at the entry of a grout hole, is always higher than the overburden pressure at the level of injection. For good grouting result, it is important to terminate grouting according to grouting pressure, not grouting volume [9]. In the following, a typical grouting termination criterion commonly put in the particular specification is quoted for reference. Grouting shall be stopped if one of the following criteria is met:

- Grouting pressure exceeds 5 kg / cm2 or twice the effective overburden pressure, whichever is greater.
- Intake of grout reaches 100 liters per meter of the grouting section.

The grout intake criteria are usually depends on the maximum pressure. Injection pressure criteria have generally been set relative to the vertical overburden pressure. Available injection pressure equals five times of overburden pressure (European code). In permeation grout, the injection rate for suspension grout is 6 L/min, while the chemical grouting is 8 L/min [1].

Case (1) estimating the Total quantity of each material

The cost of the grouting process depends on the true estimation of grouting intake and the grouting technique. According to the case of study, the expected volume of grouted soil and grouting materials depends on the permeation technique for grout curtain installation. For our case study, the grout curtain is install at the upstream of the dam. The split hole is the best choice for seepage control and the two rows of the hole can achieve the seepage control to a satisfactory level. In addition to the injection pressure, which was mentioned previously. The expected volume of grouted soil equal 108.06 m3 as shown in the figure (10).

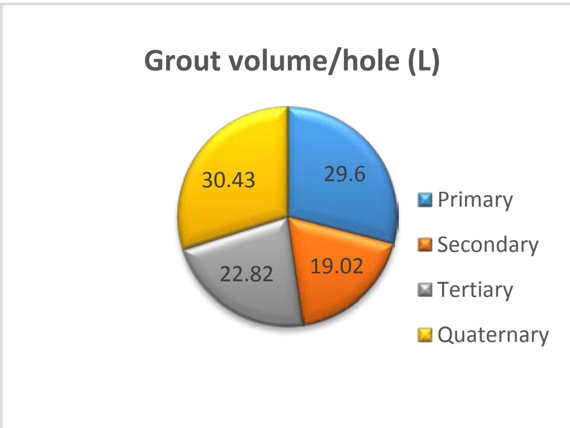


Figure 10 : the grout volume for hole of grout curtain

Based on the volume of grouted soil, the volume of grouting materials can be calculated according to (Henn 1996) equation (1) and presented in table (3) [6]. Figure (11) shows the comparison between the grouting materials by the total cost of grouting materials with permeation grout installation. Where the cost of permeation grout for suspension grouts is about $ 130 per meter of grouted soil, while the chemical grouts is about $ 200 per meter of grouted soil [1].

Table 3 : the expected volume of grouting materials (Henn1996)

Material type	Void filling factor %	Grout loss factor %	Total quantity
Water-cement	90	5	35.74
Cement- bentonite	85	5	33.75
Clay grout	85	10	35.36
Acrylamide Grout	95	15	41.32
NMA Grout	95	15	41.32
Acrylate Grout	85	10	35.36
Colloidal silica	90	10	37.44

Figure 11 : Total cost for each grouting material

Case (2) estimation the grouting materials to achieve the permeability 10-7 m/Sec

Also, Based on the data of the model and figure (1), the required volume of each grouting material can be calculated to reduce the permeability of soil from 10-4 m/sec to 10-7 m/sec as shown in table (4). To achieve this permeability of soil, it depends on the porosity of the soil before and after grouting process. The porosity of the model for the case study is 35 % at the permeability of soil 10-4 m/sec. From Casagrande formula can calculate the new porosity at the permeability 10-7 m/sec. Finally, the new porosity is 1.65 %. In addition to calculating time of injection for each grout material as presented in figure (12).

V. Soil Modeling of Grouting Materials

The most important soil property used in seepage analysis is the hydraulic conductivity. In a saturated soil, all the voids are filled with water, and the volumetric water content is equal to the porosity of the soil. All data used in the model mentioned in the table (5) and table (6) summarizes the permeabilities used in the seepage analysis.

Table 4 : Calculation of grouting materials based on Casagrande formula [17]

Material type	The permeability reduced	The volume of required materials to achieve 1 % of porosity m^3	Total quantity required
Water-cement	$1X10^{-09}$	1.02	34.21
Cement-bentonite	$4\ X10^{-08}$	0.994	33.15
Clay grout	$3.4\ X10^{-07}$	1.03	34.68
Acrylamide	$1\ X10^{-12}$	1.18	39.38
NMA Grout	$1\ X10^{-12}$	1.18	39.38
Acrylate	$1\ X10^{-5}$	Cannot reach	—
Colloidal silica	$2\ X10^{-09}$	1.07	35.92

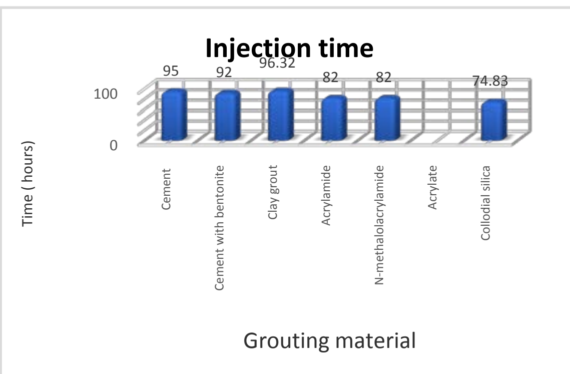


Figure 12 : Time of injection for each grout material

Table 5 : Property of Soils

Parameter	Name	Unit	Soil
Material model	Model	-	Sandy soil
Type of material behavior	Type	-	Drained
Soil unit weight	γsat	KN/m^3	15
Permeability	K	M/s	.0001
Young's Modulus	E	KN/m^2	20000
Void ratio	e	-	.53
Poisson's ratio	ν	-	0.3
Porosity	n	%	35
Cohesion	c	-	0
Friction angle	Φ	-	35

Table 6: Permeability of Materials Used in Seepage Analysis

Material	Permeability (m/s)	Description
Sand	$1X10^{-4}$	Sandy Soil
Neat cement	$1X10^{-9}$	Grout curtain
Cement/bentonite	$4X10^{-8}$	Grout curtain
Bentonite slurry	$3.4X10^{-7}$	Grout curtain
Acrylamide	$1X10^{-12}$	Grout curtain
NMA grout	$1X10^{-12}$	Grout curtain
Acrylate grout	$1X10^{-5}$	Grout curtain
Colloidal silica	$2X10^{-9}$	Grout curtain

Case (3) changes in the depth of curtain grout

This case shows the seepage analysis to assign the seepage quantity under the dam based on the change of curtain depth and different grouting materials where the curtain grout equals (50 cm).

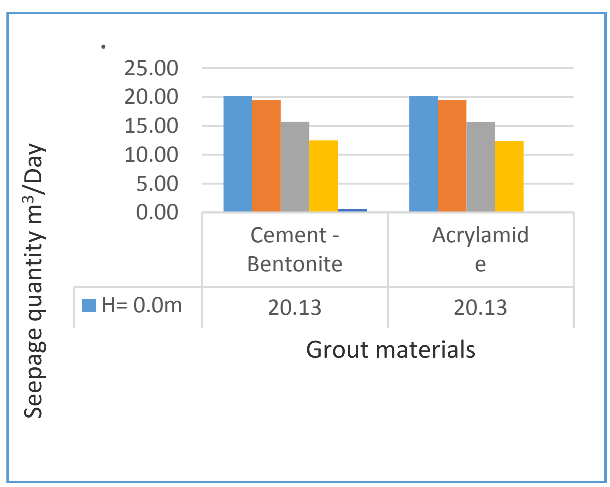
Case (4) changes in the width of curtain grout

The width of curtain grout depends on the number of lines. So based on seepage analysis and different grouting materials, the effect of the number of the row of the grout curtain can be defined. In the case of study, the depth of grout curtain is 9.0 m and the width of the of grout curtain changes.

VI. Results and Discussions

Case (3): change in the depth of curtain grout

The result of the seepage analysis of the modeled dam (Cement - Bentonite and acrylamide grout), shows a seepage quantity under the dam based on the change of curtain depth and different grouting materials for the seepage reduction as shown in Figures (13).



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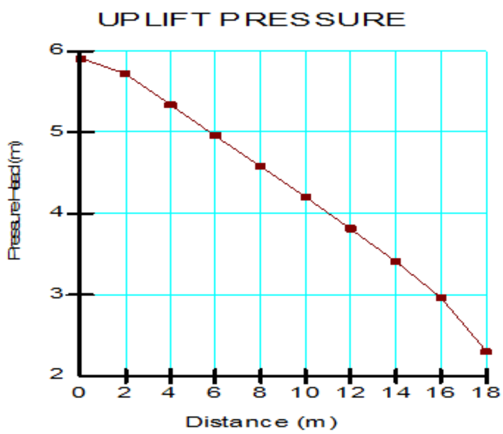
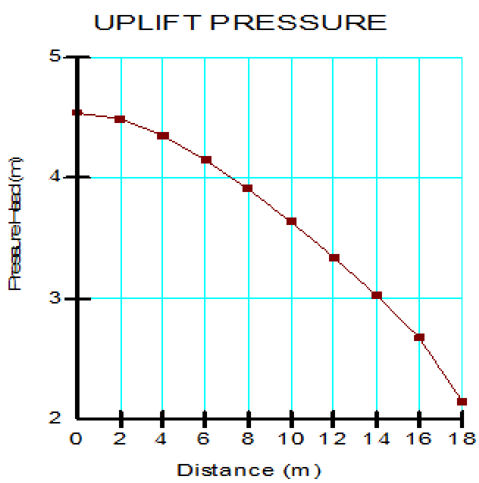
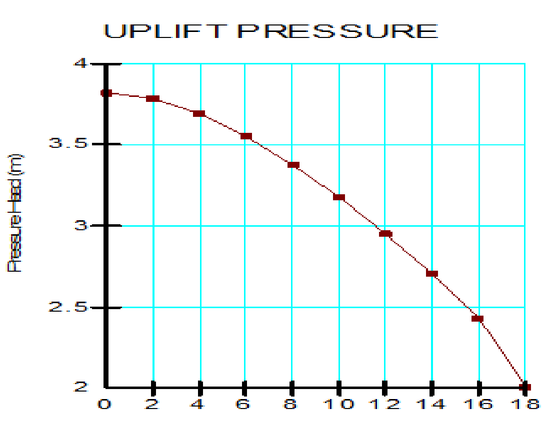
In addition to the uplift pressure under the dam that can be extracted from the seepage analysis, there is only one type of the suspension grout (cement bentonite grout) as shown in figure (14).



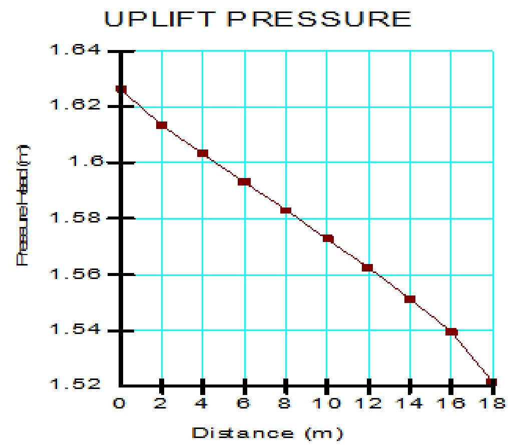
A) depth = 3.0m



B) Depth = 6.0 m



C) Depth = 9.0 m

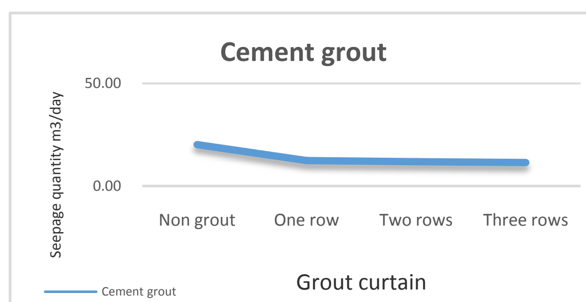


D) Depth = 14.0 m

Figure 14 : A, B, C, D Uplift pressure under the base of the dam (cement bentonite grout)

Case (4): Change in the width of curtain grout: The width of curtain grout depends on the number of lines either single or multiple row. In this case of study, the depth is constant (1.5H = 9.0m) and width of the grout curtain equal (0.5 & 1.0 & 1.5m). Figure (15) shows the effect of changing width for the cementious grouting on seepage control. Also, figure (16) shows the effect of changing width for the chemical grouting on seepage control.

a)



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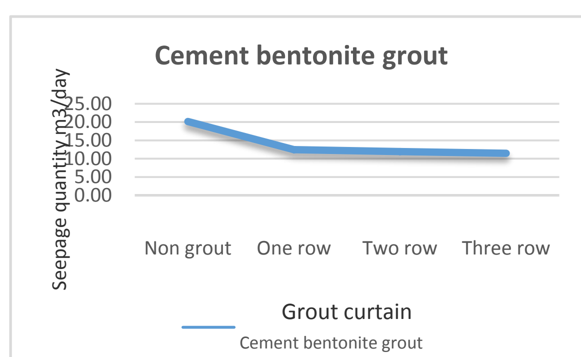

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c)

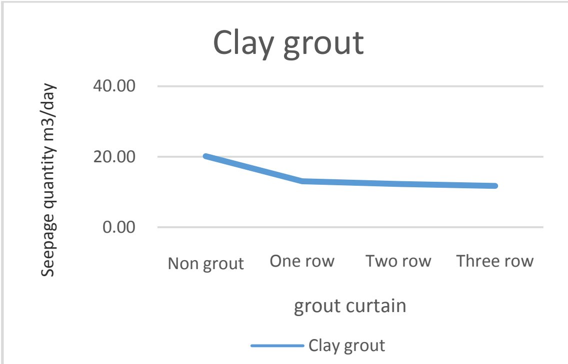
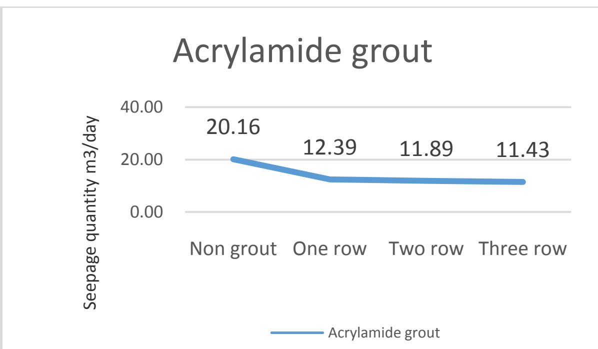
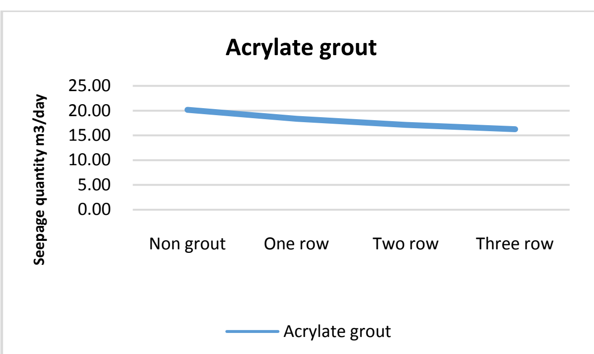


Figure 15 : a, b, c the Result of width effect of suspension grout where (D = 1.5H & width = 1, 2, 3 rows

d)



e)



f)

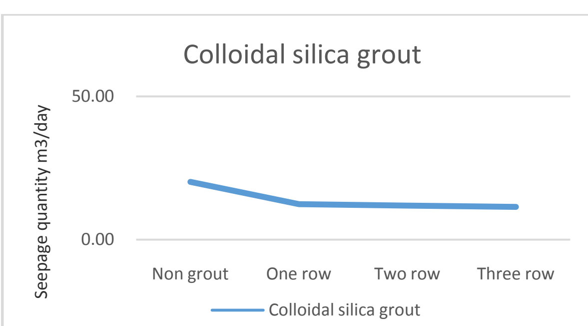


Figure 16 : d, e, f the Result of width effect of chemical grout where (D = 1.5H & width = 1, 2, 3 rows

VII. Conclusion

The efficiency of grouting depends mainly upon the penetration of grouting material through the pores of sand and the percent of fine particles in the sand. Based on the case of study and references can extract the following:

1) In acrylamide grout, creep can occur nearly 20 % so, the use of acrylamide grouts should be limited to seepage reduction.
2) NMA grout will be stable, but it absorbs water up to 200 % of its original volume, so the use of these grout should be limited to seepage reduction because of swelling.
3) Under repeated cyclic loading, chemical grouting is better in use than the cementious grouting because of its fragile behavior. The destruction of bond for chemical grouting would be partial, while the destruction of bond for cementious would be full.
4) In our case of study, the acrylamide grout can reduce the permeability up to 40 % at one row of curtain grout and the exit gradient up to zero. But this grout is more expensive and toxic.

Can be recommended, the best type of grouting materials in Egypt is a cement- bentonite grout for seepage reduction. Cement - bentonite grout can be excellent grout, available alternative material and it also lee expensive than the other materials.

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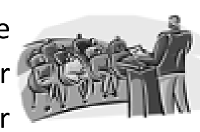
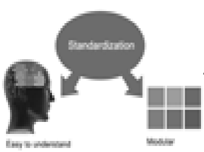


You may join as member of the Editorial Board of Global Journals Incorporation (USA) after successful completion of three years as Fellow and as Peer Reviewer. In addition, it is also desirable that you should organize seminar/symposium/conference at least once.

We shall provide you intimation regarding launching of e-version of journal of your stream time to time.This may be utilized in your library for the enrichment of knowledge of your students as well as it can also be helpful for the concerned faculty members.

The FARSE can go through standards of OARS. You can also play vital role if you have any suggestions so that proper amendment can take place to improve the same for the benefit of entire research community.

As FARSE, you will be given a renowned, secure and free professional email address with 100 GB of space e.g. johnhall@globaljournals.org. This will include Webmail, Spam Assassin, Email Forwarders,Auto-Responders, Email Delivery Route tracing, etc.



The FARSE will be eligible for a free application of standardization of their researches. Standardization of research will be subject to acceptability within stipulated norms as the next step after publishing in a journal. We shall depute a team of specialized research professionals who will render their services for elevating your researches to next higher level, which is worldwide open standardization.

The FARSE member can apply for grading and certification of standards of their educational and Institutional Degrees to Open Association of Research, Society U.S.A. Once you are designated as FARSE, you may send us a scanned copy of all of your credentials. OARS will verify, grade and certify them. This will be based on your academic records, quality of research papers published by you, and some more criteria. After certification of all your credentials by OARS, they will be published on your Fellow Profile link on website https://associationofresearch.org which will be helpful to upgrade the dignity.

The FARSE members can avail the benefits of free research podcasting in Global Research Radio with their research documents. After publishing the work, (including published elsewhere worldwide with proper authorization) you can upload your research paper with your recorded voice or you can utilize chargeable services of our professional RJs to record your paper in their voice on request.

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The FARSE is eligible to earn from sales proceeds of his/her researches/reference/review Books or literature, while publishing with Global Journals. The FARSE can decide whether he/she would like to publish his/her research in a closed manner. In this case, whenever readers purchase that individual research paper for reading, maximum 60% of its profit earned as royalty by Global Journals, will be credited to his/her bank account. The entire entitled amount will be credited to his/her bank account exceeding limit of minimum fixed balance. There is no minimum time limit for collection. The FARSE member can decide its price and we can help in making the right decision.

The FARSE member is eligible to join as a paid peer reviewer at Global Journals Incorporation (USA) and can get remuneration of 15% of author fees, taken from the author of a respective paper. After reviewing 5 or more papers you can request to transfer the amount to your bank account.

MEMBER OF ASSOCIATION OF RESEARCH SOCIETY IN ENGINEERING (MARSE)

The ' MARSE ' title is accorded to a selected professional after the approval of the Editor-in-Chief / Editorial Board Members/Dean.

The "MARSE" is a dignified ornament which is accorded to a person's name viz. Dr. John E. Hall, Ph.D., MARSE or William Walldroff, M.S., MARSE.

MARSE accrediting is an honor. It authenticates your research activities. After becoming MARSE, you can add 'MARSE' title with your name as you use this recognition as additional suffix to your status. This will definitely enhance and add more value and repute to your name. You may use it on your professional Counseling Materials such as CV, Resume, Visiting Card and Name Plate etc.

The following benefitscan be availed by you only for next three years from the date of certification.

MARSE designated members are entitled to avail a 25% discount while publishing their research papers (of a single author) in Global Journals Inc., if the same is accepted by our Editorial Board and Peer Reviewers. If you are a main author or co-author of a group of authors, you will get discount of 10%.

As MARSE, you will be given a renowned, secure and free professional email address with 30 GB of space e.g. johnhall@globaljournals.org. This will include Webmail, Spam Assassin, Email Forwarders,Auto-Responders, Email Delivery Route tracing, etc.

We shall provide you intimation regarding launching of e-version of journal of your stream time to time.This may be utilized in your library for the enrichment of knowledge of your students as well as it can also be helpful for the concerned faculty members.

The MARSE member can apply for approval, grading and certification of standards of their educational and Institutional Degrees to Open Association of Research, Society U.S.A.

Once you are designated as MARSE, you may send us a scanned copy of all of your credentials. OARS will verify, grade and certify them. This will be based on your academic records, quality of research papers published by you, and some more criteria.

It is mandatory to read all terms and conditions carefully.

Auxiliary Memberships

Institutional Fellow of Open Association of Research Society (USA)-OARS (USA)

Global Journals Incorporation (USA) is accredited by Open Association of Research Society, U.S.A (OARS) and in turn, affiliates research institutions as “Institutional Fellow of Open Association of Research Society” (IFOARS).

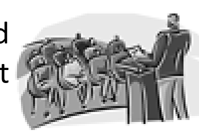
The “FARSC” is a dignified title which is accorded to a person’s name viz. Dr. John E. Hall, Ph.D., FARSC or William Walldroff, M.S., FARSC.

The IFOARS institution is entitled to form a Board comprised of one Chairperson and three to five board members preferably from different streams. The Board will be recognized as “Institutional Board of Open Association of Research Society”-(IBOARS).

The Institute will be entitled to following benefits:

The IBOARS can initially review research papers of their institute and recommend them to publish with respective journal of Global Journals. It can also review the papers of other institutions after obtaining our consent. The second review will be done by peer reviewer of Global Journals Incorporation (USA) The Board is at liberty to appoint a peer reviewer with the approval of chairperson after consulting us.

The author fees of such paper may be waived off up to 40%.



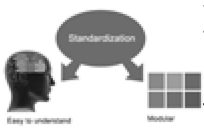
The Global Journals Incorporation (USA) at its discretion can also refer double blind peer reviewed paper at their end to the board for the verification and to get recommendation for final stage of acceptance of publication.

The IBOARS can organize symposium/seminar/conference in their country on behalf of Global Journals Incorporation (USA)-OARS (USA). The terms and conditions can be discussed separately.

The Board can also play vital role by exploring and giving valuable suggestions regarding the Standards of “Open Association of Research Society, U.S.A (OARS)” so that proper amendment can take place for the benefit of entire research community. We shall provide details of particular standard only on receipt of request from the Board.

The board members can also join us as Individual Fellow with 40% discount on total fees applicable to Individual Fellow. They will be entitled to avail all the benefits as declared. Please visit Individual Fellow-sub menu of GlobalJournals.org to have more relevant details.

We shall provide you intimation regarding launching of e-version of journal of your stream time to time. This may be utilized in your library for the enrichment of knowledge of your students as well as it can also be helpful for the concerned faculty members.



After nomination of your institution as “Institutional Fellow” and constantly functioning successfully for one year, we can consider giving recognition to your institute to function as Regional/Zonal office on our behalf.

The board can also take up the additional allied activities for betterment after our consultation.

The following entitlements are applicable to individual Fellows:

Open Association of Research Society, U.S.A (OARS) By-laws states that an individual Fellow may use the designations as applicable, or the corresponding initials. The Credentials of individual Fellow and Associate designations signify that the individual has gained knowledge of the fundamental concepts. One is magnanimous and proficient in an expertise course covering the professional code of conduct, and follows recognized standards of practice.

Open Association of Research Society (US)/ Global Journals Incorporation (USA), as described in Corporate Statements, are educational, research publishing and professional membership organizations. Achieving our individual Fellow or Associate status is based mainly on meeting stated educational research requirements.

Disbursement of 40% Royalty earned through Global Journals : Researcher = 50%, Peer Reviewer = 37.50%, Institution = 12.50% E.g. Out of 40%, the 20% benefit should be passed on to researcher, 15 % benefit towards remuneration should be given to a reviewer and remaining 5% is to be retained by the institution.

We shall provide print version of 12 issues of any three journals [as per your requirement] out of our 38 journals worth $ 2376 USD.

Other:

The individual Fellow and Associate designations accredited by Open Association of Research Society (US) credentials signify guarantees following achievements:

- The professional accredited with Fellow honor, is entitled to various benefits viz. name, fame, honor, regular flow of income, secured bright future, social status etc.

- In addition to above, if one is single author, then entitled to 40% discount on publishing research paper and can get 10%discount if one is co-author or main author among group of authors.
- The Fellow can organize symposium/seminar/conference on behalf of Global Journals Incorporation (USA) and he/she can also attend the same organized by other institutes on behalf of Global Journals.
- The Fellow can become member of Editorial Board Member after completing 3yrs.
- The Fellow can earn 60% of sales proceeds from the sale of reference/review books/literature/publishing of research paper.
- Fellow can also join as paid peer reviewer and earn 15% remuneration of author charges and can also get an opportunity to join as member of the Editorial Board of Global Journals Incorporation (USA)
- • This individual has learned the basic methods of applying those concepts and techniques to common challenging situations. This individual has further demonstrated an in–depth understanding of the application of suitable techniques to a particular area of research practice.

Note :

"

- In future, if the board feels the necessity to change any board member, the same can be done with the consent of the chairperson along with anyone board member without our approval.
- In case, the chairperson needs to be replaced then consent of 2/3rd board members are required and they are also required to jointly pass the resolution copy of which should be sent to us. In such case, it will be compulsory to obtain our approval before replacement.
- In case of "Difference of Opinion [if any]" among the Board members, our decision will be final and binding to everyone.

"

Process of submission of Research Paper

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

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

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

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

(II) Choose corresponding Journal.

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

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

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

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

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Page Size: 8.27" X 11'"

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

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

1. General,

2. Ethical Guidelines,

3. Submission of Manuscripts,

4. Manuscript’s Category,

5. Structure and Format of Manuscript,

6. After Acceptance.

1. GENERAL

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

Scope

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

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2. ETHICAL GUIDELINES

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

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

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

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

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

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

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

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

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

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

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

3. SUBMISSION OF MANUSCRIPTS

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

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

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

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

4. MANUSCRIPT'S CATEGORY

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

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

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

Research articles: These are handled with small investigation and applications

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

5.STRUCTURE AND FORMAT OF MANUSCRIPT

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

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

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

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

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

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

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

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

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

(h) Brief Acknowledgements.

(i) References in the proper form.

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

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

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

Format

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

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

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

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

Structure

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

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

Abstract, used in Original Papers and Reviews:

Optimizing Abstract for Search Engines

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

Key Words

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

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

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

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

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

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

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

Acknowledgements: Please make these as concise as possible.

References

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

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

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

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

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

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

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

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

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

6. AFTER ACCEPTANCE

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

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

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

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

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

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

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

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

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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.

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

Informal Guidelines of Research Paper Writing

Key points to remember:

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

Final Points:

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

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

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

General style:

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

To make a paper clear

· Adhere to recommended page limits

Mistakes to evade

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

In every sections of your document

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

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

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

· Align the primary line of each section

· Present your points in sound order

· Use present tense to report well accepted

· Use past tense to describe specific results

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

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

Title Page:

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

Abstract:

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

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

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

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

Approach:

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

Introduction:

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

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

Approach:

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

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

Procedures (Methods and Materials):

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

Materials:

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

Methods:

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

Approach:

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

What to keep away from

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

Results:

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

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

Content

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

What to stay away from

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

Approach

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

Figures and tables

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

Discussion:

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

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

Approach:

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

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

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

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

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

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

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

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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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