ECO - MANAGEMENT OF PAKISTAN'S COASTS AND HARBOURS

*Engineer Mumtaz Hussain

ABSTRACT

Coastline of Pakistan extends to about 990 Kilometers along the Arabian Sea stretching from Indus Delta to Gwadar Bay. Pakistan enjoys the strategic position from maritime and merchant trading angles, being situated at the confluence of Arabian Gulf and Indian Ocean. In terms of marine pollution, the Makran Coast is much lesser degraded than the Sindh Coast. There is abundance of biota available in the sea, although certain species are facing extinction because of higher pollution levels in the coastline of Karachi. Indus had the fifth largest delta in the world. The mangroves cover an area of 333,333 hectares. The Coastline is blessed with a number of harbour areas. Major sea ports are Karachi and Port Qasim. Prominent Fish Land Centres are Ketibundar, Gaddani, Dam Sonmiani, Ormara and Jiwani. Fish Harbours are Korangi, Ibrahim Haideri, Karachi, Pasni and Gwadar. Ormara has recently been developed as a harbour. The coastal water of Karachi Harbour is being polluted at an alarming dimension. The pollution profile of Karachi Harbour vividly indicates the deteriorating scenario of marine resources including the coral reefs. The sources of environmental pollution are land, sea and air. The pollutants are organic and inorganic in nature and are generated mainly from industrial and municipal origins in addition to those produced from the visiting vessels and dredging operations. The Exclusive Economic Zone of Pakistan extends to 200 nautical miles from the coast which measures to 110,000 square nautical miles. The area is of great economic significances, therefore there is deep requirement of protecting it from the ill effects of environmental stresses and strains. For smooth and efficient port functioning and economic activities the harbours (especially the Karachi Harbour) are required to be made environmentally sound. Prior to planning and designing a port. Environmental Impact, Assessment needs to be undertaken at the feasibility stage. There is no denying the fact that eco-issues dominate the other financial, administrative, socio-economic and technical considerations for the sustainable biological productivity of the seas and oceans. This is particularly true in case of highly polluted coastal waters of the developing countries and Pakistan is no exception on it.

PREAMBLE

Coastal Belt

The coastline of Pakistan extends to about 990 Kilometers along the Arabian Sea. It stretches from eastern edge of Indus Delta to the Gwadar Bay at Ras Fastah covering Sindh and Balochistan provinces. The River

*Chairman, Environment Media Forum Pakistan.

Dasht falls into the Arabian Sea at the Ras Fastah. The lengths of coastline in Sindh and Balochistan are 245 and 745 kilometers respectively. The coastal areas get the various shapes of penisulas and the bays.

2. The Territorial Water encompasses a depth of 12 nautical miles. The Exclusive Economic Zone lies upto 200 nautical miles covering an area of 110,000 squares nautical miles.

BIOLOGICAL PRODUCTIVITY

3. The coast of Pakistan is rich in flora and fauna. Sea food comprises of 400 species of fishes, 25 species of shrimps, 3 species each of crabs and spiny lobsters. The shrimps are famous all over the world and are exported in large quantity. The shrimps found in stony beaches and the mangroves are extremely delicious. Green and Olive turtles are found in large number along the beach at many places. The Planktons grow in the cleaner and calm portions of the sea. Many sea birds add to the recreational aspects. Whales and dolphins are rarely found. Blind Dolphin of Indus River is recognised globally and is the attraction for the research specialists.

4. Indus Delta is the fifth largest in the world. Channels in the delta are inactive. The water has a lower level of salinity thus it is suitable for the growth of distinct species. They are of paramount importance commercially and environmentally.

5. Coral reefs are found in sea bed of Makaran Coast in patches. They play a dominant role in the sub surface ecosystem. These are sparingly available in the polluted water of Karachi Coast.

COASTAL ECOSYSTEM

Imbalances

6. The coastal ecosystem is constantly being threatened by a number of factors. People themselves are responsible for the damage caused to the marine environment through the eco-hostile steps. The environmental imbalances and their causation are highlighted in the following:-

a) Scarcity of Fresh Water

Presently 33 million acre feet (MAF) of water flows into the Indus Delta in many channels. Any further reduction of flow due to construction of upstream barrages is likely to adversely effect the natural habitat for the mangroves and other flora and fauna. This will also reduce the influx of the fertile siltation. Minimisation of inflow of river water results in increase of waterlogged and marshy areas. Many creeks and rivulets have developed in the deltaic region. During the flooding season the Delta receives large amount of water on account of which the salinity level remains within favourable limits. The sediment load brought during winter season is much lesser than that brought in the flooding period.

b) Excessive Marine Pollution

i) Gaddani Beach and Karachi Harbour are the worst polluted places in the entire region. Gaddani Beach has the flourishing ship breaking industry. The old ships carry all sorts of wastes including the hazardous wastes.

ii) Karachi Harbour receives pollution from land, air and sea sources.

Land Pollution

The industrial and municipal effluents and wastes to the tune of 362 million gallons flow in the harbour area. River Lyari receives the industrial effluents and wastes from Sindh Industrial Trading Estate. River Malir is contaminated from the effluents and wastes from Sindh Industrial Trading Estate. River Malir is contaminated from effluents and wastes generated in Koangi and Landhi Industrial Areas. Daily Bio- Chemical Oxygen Demand load of Rivers Lyari and Malir are 615 and 550 tonnes respectively. Both Karachi and Port Qasim handle about 35 million tonnes of normal cargo and one million tonne hazardous cargo. The wastes thus generated also find their way in the Arabian sea. The marine biota in general show higher contamination of antimony, Arsenic, Cadmium and Chromium than the permissible limits. However heavy metals like land, Mercury and. Zinc were also detected in the marine species but not in the alarming proportions. About 600 tonnes waste also enters the Harbour from the adjoining localities.

Pollution from Sea

Karachi Harbour has 100 harbour crafts and 2,000 fishing trawlers. The visiting vessels number about 2,000 per year. In addition sometimes the ships carrying oil and injurious chemicals sink and pose a serious threat for the marine life. Dredging operations cause damage to Coral and Oyster beds and Planktons. Oil spills destroy the mangroves and other marine resources, recreational spots and port activities. Because of crude oil the reefs, rocks and shoreline become oily and black. The spill is mostly generated from the oil tankers, shoreline oil wells and beach oil washings.

Atmospheric Pollution

The vessels generate injurious gases, particulates and unburnt carbon from their exhausts and chimneys. The hazardous chemicals emit fumes which may cause death to the crew and the marine biota. There are other sources like chemical plants, oil storages, thermal power plants and burning of wastes which degrade fragile eco- systems.

c) The mangrove ecosystem is

being destroyed by overgrazing, cutting of trees for fuel wood purpose, lack of afforestation and non supply of fresh water.

d) Erosion of coastline is being done by the sea water due to reduced carriage of sediment load. This phenomenon is further aggravated by the accretion and retrogression actions occurring along the coastline. Coastal soil is queried unabated resulting in denudation of the beach and the breeding places of the turtles and other biota.

ECO-SAFE PARA-METERS AND KARACHI PORT

7. Karachi Port has been declared as one of the dirtiest ports in the world. It is so much polluted that from any set of standards its status as an eco-friendly port is questionable. In the following critical analysis is carried out whether the required parameters had been observed at designing and construction stages or otherwise.

8. Planning Stage

a) Feasibilities like technical administrative, economic site conditions, environment, natural and artificial barriers and aesthetics are considered at the planning stage in order to ascertain the viability of the port as a beneficial project. In addition to other studies "Environment Impact Assessment" is done in detail so as to satisfy the National Environment Protection Law and Quality Standards. It seems as if this aspect has been ignored at that moment.

b) The overriding technical consideration is the protection of the proposed site against the open wave action and the wind so that the port functions may be performed with maximum operational efficiency, safety and security. The projected traffic density of all kinds of ships including cargo and oil tankers is another important criterion. The stagnant back waters of Manora Channel are the main causation of pollution in Karachi Harbour. It is ironic that the pollution profile of this Harbour is not regularly done. It is worth noting that 75% of the untreated effluent reaches the Manora Channel through the Lyari River. Only 25% of the total effluent falls in the Gizri- Korangi Creek via Malir River.

c) The mangroves not only protect the marine life at least once in their life cycle but also help in stabilization of the shoreline. Therefore, these are the assets of a port. Karachi harbour has large area covered by the mangroves but because of heavy organic loading of waste water, oil spills and oil washings, the mangroves are fast shrinking. Oil terminals must be sited away from mangroves.

d) A sheltered site is ideal for development of a port. At the same time it is suitable for the propagation of sea life. Thus there is necessity of relocating the site as far as possible in order to safeguard the coral and oyster beds.

e) Separate facilities be provided for handling of liquid and dry cargo,. storage of oil, gas and chemicals and oil and gas terminals.

f) The fool proof communication and navigation arrangements do not exist. Only rudimentary and adhoc measures are taken to meet the emergency situation. Environmental disasters could be controlled by avoiding accidents and immediate recovery of the sunken ships, equipment and materials.

g) Karachi Port is not equipped with the facility of vessel collection of the waste from the visiting vessels and then subsequent disposal. Presently, most of the ships off- load the wastes in the open sea near the Port. This situation is environmental hazards of the highest order. This requires the well conceived waste management system encompassing the waste collection from the vessels, off loading at the port site and transferring to the disposal site where the waste undergoes proper treatment and finally disposed.

h) **Impact of Currents**

During winter the polluted water is carried westwards along Makran Coast. In summer the polluted water is pushed towards the mangroves in the Deltaic region. Thus degradation of mangrove environment disturbs the life cycle of most of the fauna. Overall there is reduction in the fish yield.

INTEGRATED COASTAL ZONE MANAGEMENT

Concept

9. The Coastal Zone of Pakistan is not being managed in a proper manner. The operations of harbour and port needs to be dovetailed with marine tourism and recreational activities. The concept of "Integrated Coastal Zone Management" covers the following aspects :-

a) Marine/beach tourism

b) Conservation of marine environment

c) Marine and coastal ecosystem planning

d) Protection of sound coastal engineering

f) Eco- friendly harbour and port development

g) Mitigation of marine pollution

h) Control of coastal hazards and mining

I) Preservation of coastal cultural heritage.

j) Provision of amusement parks, sport fields, hostels, motels and restaurants.

k) Improvement of sea bed environment including coral reef and oyster beds.

l) Popularization of oceanography as a discipline.

m) Research and development activities

IMPLEMENTATION STRATEGY

10. As a matter of policy all concerned agencies/departments such as Maritime

Security Agency, Maritime Pollution Control Board, Center of Excellence in Marine Biology University of Karachi, Coast Guards, Pakistan Steel Mill, National Refinery, National Institute of Oceanography, Karachi Shipyard and Engineering Works, Karachi Port Trust, Port Qasim Authority, Karachi Fish Harbour, Gwadar Fish Harbour, Environment Protection Agency Sindh, Karachi Chamber of Commerce and Industry, Karachi Metropolitan Corporation, Karachi Water and Sewerage Board and NGOs.

DEVELOPMENT OF MASTER PLAN

11. Ten year Master Plan be chalked out in consultation with the interested parties, covering all the facts of sustainable port and general public, mass awareness programmes be run through the media so that they may also suggest certain uplift measures.

FINANCIAL BACKUP

12. For the success of the Master Plan regular flow of funds both for development works and the maintenance/repair programmes be ensured. The financial agencies like International Monetary Fund, World Bank, Islamic Bank, Asian Bank may be consulted for provision of funds.

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DESIGN OF SLOPE PROTECTION AND LAUNCHING APRONS

*Engr. Mahmood Ahmad Sulehri**

1. GENERAL

The slopes of river banks, spurs, canals, rail or road embankments, excavations, etc., are stone pitched to preserve and protect them from rain, wave-wash and other weathering agents. This pitching is properly toed down by providing a stable foundation, and it is usual to provide an adequate length of horizontal bed pitching called the apron where deep bed scours are anticipated. The limits of guidelines for design of such works are so wide that there is a need for establishment of a rational criteria. Therefore, a rational approach for the design of slope protection (stone pitching) and launching aprons is presented.

A computer program suitable for pocket computers is also included. This program can be easily converted to run on any personal computer. This reasonably interactive program can design free borad, stone pitching, at-grade launching aprons and slanting aprons in addition to calculation of scour depth.

2. SLOPE PROTECTION

Stone pitching is used for protection of earthen embankment slopes against weathering and wave-wash. Important components are free board, thickness of stone pitching, size and quality of stone. The general guidelines for design of stone pitching follow.

2.1 FREE BOARD

Free board is the vertical height between the designed high flood level (H.F.L) and the top of the embankment. It should be such that there will be no danger of overtopping, even with intense wave-wash. Free board forms a vital component of a slope protection as a fairly large number of embankments get washed due to overtopping that takes place due to inadequate free board.

The extent of wave action depends on the "fetch" or the longest line of exposure of water surface to the wind. For the height of waves, which depend upon wind velocity, there are standard formulae, such as Stevenson's.

$$h_w = 0.032\,(V \times F)^{1/2} + 0.763 - 0.271\,(F)^{1/4} \qquad \text{(Eqn. 1)}$$

(for F<32 Km)

where;

h_w = Height of waves in meters.

F = "Fetch" in Kms.

V = Wind Velocity in Km/hour.

Wind velocity is usually in the range of 80-160 Km/hour (50-100 mph). Where wind velocity is not known, a value of 120 Km/hour (75 mph) may be assumed. The minimum free-board is thus:

$$H = 1.5 \times h_w \qquad [H \geq 1\text{ m or }3\text{ Ft}] \qquad \text{(Eqn. 2)}$$

*Principal Engineer, NESPAK

For a fetch of 1 mile the height of wave will be 3 feet and minimum free-board will be 4.5'. The above equations give a conservative value of free-board for river embankments, because they apply to free or exposed water surface such as dam reservoirs. In case of rivers, the height of wave will be much smaller due to factors like limited length of fetch, depth of water, wind direction, growth of trees and/or weeds and presence of Belas, etc.

Alternatively, free-board can be selected on the basis of either fetch (in miles) or depth of water (in ft. determined from the designed H.F.L) from Table-1.

Table - 1

FREE BOARD		
Fetch (miles)	Free Board (Ft)	Depth of water
< 1	3	5'-10'
1	4	10'-15'
2.5	5	15'-20'
5	6	20'-25'
10	7	25'-50'

Although in exceptional instances the free board for a river embankment can go up to 10', generally, it varies from 3' to 5'. A typical free-board height of 5' over the designed H.F.L. is considered a sufficient margin to offset both an unexpected rise during the flood season and the height of waves from overtopping the crest of the embankment.

2.2 THICKNESS OF STONE PITCHING

The pitching is graded by having a layer of spawls or finer material under the stone which is known as backing or sub-grade and is compacted well. Spawls as well as pitching are done simultaneously. The thickness of pitching depends upon the force of water current to which it is to be subjected. Spurs and flood embankments have usually 2' thick pitching made up of 0.7' spawls and 1.3' stone (see Fig. 1).

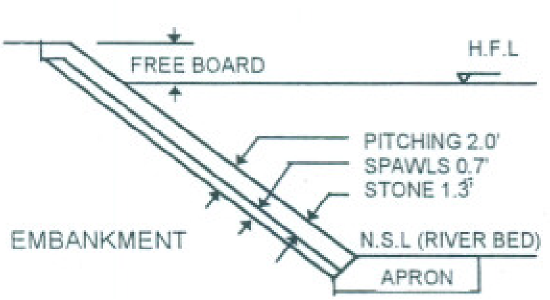


Figure 1: Slope protection with ordinary stone pitching.

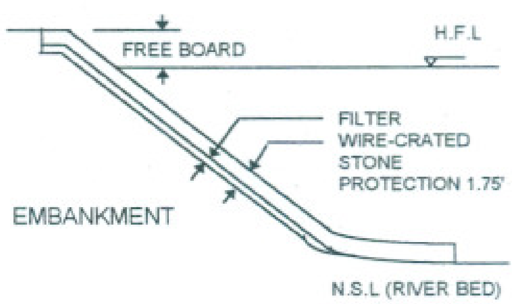


Figure 2: Slope protection with Reno Mattress.

Another option is to provide about 0.5 m (≅ 1.75') thick wire crated stone gabions in the form of ***RENO MATTRESS*** over a filter layer or cloth for protection of embankment slopes of rivers, lakes and canals (see Fig. 2). Theoretically, thickness of pitching may be calculated by the following relationship.

$$T_s = 0.06\, Q^{1/3} \qquad \text{(Eqn. 3)}$$

where;

Q = Total discharge in cumec,

T_s = Thickness of stone pitching in meters.

Where the soil is composed of shingle, gravel and clay, spawl may not be used. Instead, a 1.5' thick layer of stone pitching without spawl may be provided over a well compacted shingle/gravel (embankment) material.

On the slopes of high embankments subject to intensive wave-wash, a 3 ft. layer of rock is provided over 1 ft. thick graded filter layer.

It is preferable to extend the stone pitching to the top of the embankment and terminate it in a proper manner (see Fig. 1). Where economy demands, the stone pitching should be extended above the HFL for at least half of the free board but not less than 3 ft.

2.3 SIZE AND QUALITY OF STONE

Stones should be as big as possible up to the size of the pitching and laid closely and firmly bedded with their length perpendicular to the face of pitching. The stone must be durable and tough. Surface of the pitching must be left rough and not dressed to smoothness, because rough surface is more effective for guarding against wave-wash. Normally pitching should be done by quarried blocky stone. Boulders are only used where they are available locally. Average weight of stone used for pitching should be 80 pounds (about 1 ft. in size).

It is very important to compact the dressed embankment before pitching stones are laid. The compaction should be such that embankment can sustain pitching weight without settling. This factor is very important where the soil is clayey in nature that consolidates and settles. It is advisable that compaction should be at optimum moisture content.

On sharp curves and/or bends the stability of the slope protection should be checked against velocity of water. This may be reasonably achieved by determining the minimum size of stone required to sustain a particular velocity. Although changes in geometry of embankments are covered by the factor of safety (x), it will be a safer practice that at such locations a reasonable flow concentration factor may be assumed to cater for abrupt changes in the geometry of the components.

3. LAUNCHING APRON

As mentioned under Section-1 above it is necessary to provide a wide stone apron of suitable thickness at the toe of the pitched slope or at upstream and downstream of weir structure for protection against scour.

3.1 LAUNCHING APRONS WITH EMBANKMENTS

Launching aprons provided at the toe of embankments are not only to support the slope pitching but also to protect it from being damaged by slipping down due to the scouring of the river bed. Without an apron, the stone-pitched slope would obviously slip into any scour hole that is formed at the toe of the pitching. The stone apron would cater for all scour-induced stone slipping into the scour hole that is necessary and thus keep the pitched face intact. The thickness of an apron must be such that it will be flexible enough to fold downwards, but also has sufficient weight to remain in position on the bed. From experience, it has been found that 1.75 to 2.0 ft. (0.5 meter) thick wire-crated stone (gabion) apron and 2.5 to 3.0 ft. thick loose stone apron meet these conditions in most of the cases. The thickness, however, should not be greater than 6.5 ft. (2 m).

Design of a stone apron would depend upon the following factors.

(i) ***Depth of maximum scour that is likely to occur.***

(ii) ***Sub-surface slope which is likely to be taken up by the side of the scour hole (slope of the launched apron).***

(iii) ***Thickness of the unerodible stone coating required on the slope of the scour hole (thickness in launched position).***

3.1.1 SCOUR DEPTH

One of the most commonly used equations for calculating scour depth is Lacey's equation which is as below:

$$R = 0.9\left(\frac{q^2}{f}\right)^{1/3} \qquad \text{(Eqn. 4)}$$

Where; R = Normal scour depth (or Lacey's regime depth) measured from H.F.L. in feet.

q = Maximum discharge per unit width (unit discharge) in Cusec/ft.

f = Lacey's silt factor for bed material (determined from Table-2). Its value is **1** for standard silt.

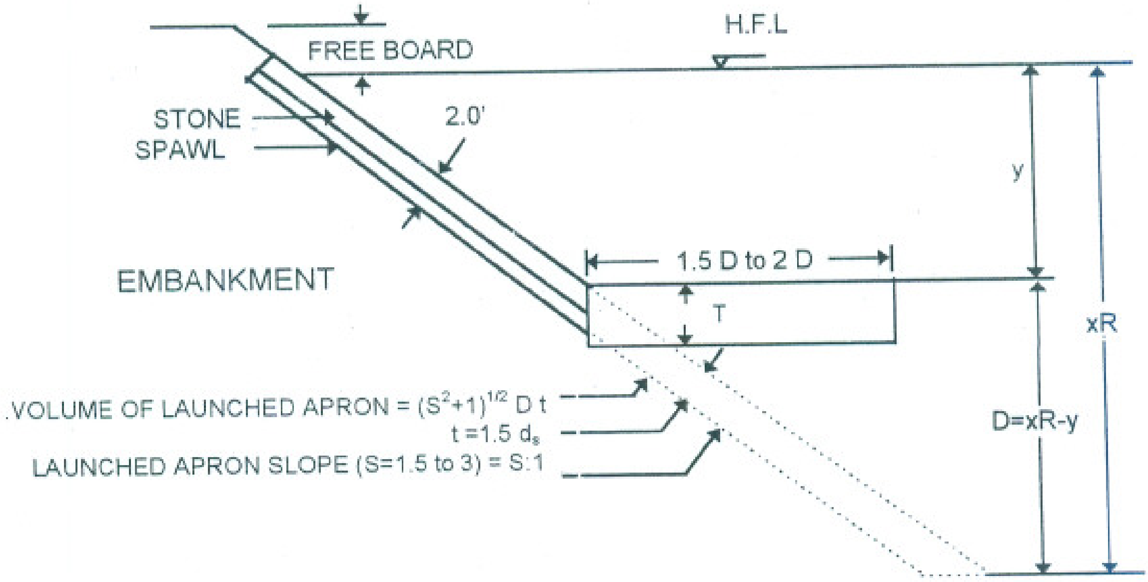


Figure 3

and,

$$D = x\,R - y \qquad \text{(Eqn. 5)}$$

where; D = The ultimate scour depth below bed level in feet.

y = The minimum depth of flow in feet.

x = Factor of safety based on condition of reach (determined from Table-3).

Table - 2

Lacey's Silt Factor " *f* *"					
Soil Type	**Grain Size (mm)**	***f***	**Soil Type**	**Grain Size (mm)**	***f***
Large Boulders and Shingle	130	20.00	Fine Bajri & Sand	0.89	1.75
Boulder and Shingle	73	15.00	Coarse Sand	0.72	1.50
Small Boulder and Gravel	50	12.50	Medium Sand	0.50	1.25
Small Boulders, Shingle & Sand	32	10.00	Standard Silt (Kennedy)	0.32	1.00
Heavy Gravel and Bajri	26	9.00	Medium Silt (Punjab Canals)	0.23	0.85
Coarse to medium Gravel	07	4.75	Fine Silt	0.05-0.15	0.40-0.70
Coarse Bajri and Sand	2.40	2.75	Very Fine Silt (0.006 mm)	0.0039-0.0078	0.4
Medium Bajri and Sand	1.29	2.00	Clay	-	5.00

* *It is preferable to calculate the value of the Lacey's Silt Factor **f** with the help of the following formula when average particle/grain size is known.*

$$f = 1.76\sqrt{d_{mm}} \qquad \text{(Eqn. 6)}$$

where; d_{mm} = average size of particle in mm.

Table - 3

FACTOR OF SAFETY FOR APRONS				
CONDITION OF REACH	VALUE OF **x**		SCOUR DEPTH	REMARKS
	Range	Mean		
Straight Reach of Guide Bank.	1.00-1.25	**1.25**	1.25 R-y	
Moderate Bend (Transition from Noses to Straight portions).	1.25-1.75	**1.50**	1.50 R-y	Also for u/s of weir.
Sever Bend.	1.75	**1.75**	1.75 R-y	
Right Angled Bend.	2.00	**2.00**	2.00 R-y	Also for d/s of weir.
Noses of Guide Banks.	2.00-2.50	**2.25**	2.25 R-y	

3.1.2 SLOPE, THICKNESS AND LENGTH OF LAUNCHED APRON

The slope and thickness of launched apron, as recommended by various researchers, differ substantially from each other. Spring recommended thickness of 3.0' over a slope of 3:1, while Gales has recommended this thickness varying from 1.35 m (4.4') to 1.9 m (6.23') for discharges ranging from 7000 to 70000 m^3/sec. (25,000 - 250,000 cusec). Blench recommended a thickness equal to twice the size of stone in apron over a slope of 2:1. The thickness recommended by Blench seems logical. Hence the thickness of the apron in the launched position be kept 1.5 times to 2.0 times the size of stone.

The size of the stone can be calculated by the relation suggested by US Bureau of Reclamation, correlating average velocity of flow and size of stone.

$$d_s = 0.0126\,(V_{av})^2 \qquad \text{(Eqn. 7)}$$

where; V_{av} = Average velocity of flow in ft./sec.
d_s = Mean diameter of stone in feet.

The recommended thickness of the apron in the launched position over a slope ranging from 1.5:1 to 3:1, varies from 2.0 to 3.25 ft (e.g., 2.5' for a slope of 2:1) for a loose stone apron. But another guideline suggests that it should be taken as 1.25 times the thickness of a properly designed slope protection, i.e., stone pitching (usually taken as 2.0' thick).

Although, it is usual to take the thickness (*t*) of the launched apron as 2 feet for the purpose of design, a more rational approach would be to take this thickness as 1.5 times the size of stone (d_s).

$$t = 1.5\,d_s \qquad \text{(Eqn. 8)}$$

where; $1.25' \leq \mathbf{t} \leq 4.5'$ for wire-crated stone apron (slanting position).
$2.0' \leq \mathbf{t} \leq 4.5'$ for loose stone apron (slanting position).

If slope in launched position (i.e. in slanting position) is S:1, where S ranges between 1.5 and 3.0, the length (*l*) of launched stone apron would be:

$$l = \sqrt{S^2 + 1^2} \times D \quad = \sqrt{S^2 + 1} \times D \qquad \text{[General expression]} \qquad \text{(Eqn. 9)}$$

$$l = 1.8 \times D \qquad \text{[Slope = 1.5:1]} \qquad \text{(Eqn. 9-a)}$$

$$l = 2.25 \times D \qquad \text{[Slope = 2:1]} \qquad \text{(Eqn. 9-b)}$$

$$l = 3.2 \times D \qquad \text{[Slope = 3:1]} \qquad \text{(Eqn. 9-c)}$$

Knowing the inclined length (*l*) and the thickness (t) , the total volume of stone can be calculated. The volume of the stone per foot run of an apron would thus be:

$$\text{Volume of apron} = l \times t \quad \text{cft} \qquad \text{[General expression]} \qquad \text{(Eqn. 10)}$$

$$= 1.8 \times D \times t \qquad \text{[Slope = 1.5:1]} \qquad \text{(Eqn. 10-a)}$$

$$= 2.25 \times D \times t \qquad \text{[Slope = 2:1]} \qquad \text{(Eqn. 10-b)}$$

$$= 3.2 \times D \times t \qquad \text{[Slope = 3:1]} \qquad \text{(Eqn. 10-c)}$$

The width or projection of the un-launched apron is designed in respect to the depth to which it must eventually drop. Experience has shown that the projection must be from 1.5 to 2 times the maximum expected depth of scour (D), for slopes of 2:1 and 3:1 respectively. The width of the apron at grade (L) is usually kept 1.5 time the depth of the maximum scour (D), since it is desirable to keep the scour hole at a distance from the slope so as to ensure a minimum sub-surface slope of 2:1. As the sub-surface slope can go up to 3:1, an at-grade width of 1.5×D would not be sufficient to cover the slope developed after the worst scouring. A more rational approach, therefore, would be to relate the launched length (*l*) to the at-grade length of apron (L). This can be expressed in the form of the following equations.

$$\text{Width of un-launched (at-grade) apron,} \quad L = 1.5 \times D \qquad \text{(Eqn. 11)}$$

$$L = l \div 1.5 \qquad \text{(Eqn. 11-a)}$$

The largest of the values obtained from the above expressions should be considered for design purposes.

The thickness of the apron at grade can be determined from the volume of the launched apron.

$$\text{Thickness of un-launched apron, } T = \text{Volume} \div L \qquad \text{(Eqn. 12)}$$
$$= (l \times t) \div L$$

also,
$$T = 1.5 \times t \qquad \text{(Eqn. 12-a)}$$

where;

$2.0' \leq \mathbf{T} \leq 6.5'$ for wire-crated stone apron (at-grade), and
$3.0' \leq \mathbf{T} \leq 6.5'$ for loose stone apron (at-grade).

Volume of apron can be obtained from Equation-10 and length of the un-launched apron can be evaluated from Equation-11.

It is economical to provide a loose stone apron in streams where velocities do not exceed 5 fps. The decision to provide loose stone apron or wire-crated stone (Gabion) apron should be based upon the judgment of the field engineer when velocities range between 6 to 10 fps. However, it is advisable to provide launching apron in wire-crated stone for velocities exceeding 10 fps.

3.2 LAUNCHING APRONS DOWNSTREAM AND UPSTREAM OF WEIR

Bed protection downstream of the structure of a weir is required to withstand turbulent erosion by the stream flow as it enters or emerges from the structure.

The procedure for determination of such launching apron is the same as given under section 3.1 above, except that the values of $\boldsymbol{x}$ (F.O.S) for upstream and downstream of the weir are taken as 1.5 and 2, respectively.

3.3 STONE-FILLED STEEL-CRATES

Steel crates are similar to wire-crates except that the mesh is fabricated from mild steel round bars. The diameter of steel bars may vary from 1/8" to 1/2". Unlike wire-crates, steel crates do not disfigure to adopt the disturbed underlying soil surface.

Not much theoretical work has been done on steel crates. However, these have been used in place of launching aprons or as bed stabilizers under certain conditions in Balochistan Province, where they have performed satisfactorily in mostl of the cases.

Stone filled steel crates have been used at d/s of weirs and at noses of spurs where wire-mesh of the wire-crated stone apron would be cut by repeated hitting of large stones, resulting from unusual velocities and turbulent flows.

Another use of stone-filled steel-crates is at the top most layer (crest) of a wire-crated stone weir, because normally they would not disfigure or damage easily with hammering of stones rolling/flowing with water.

The design criteria would normally be the same as that of wire crated stone aprons with the only exception that the steel bars will replace G.I. wire. The size of a steel crate normally varies from 3'x3'x3' to 6'x3'x3'.

It would be preferable if the mesh of steel bars is galvanised. However, due to reasons of economy and non availability of such galvanised pre-fabricated steel-crates locally, ordinary round mild steel bars can be used in fabrication of the crates in a welding shop or at site of work. Due to their high cost, stone-filled steel-crates should not be used very frequently, but only where conditions dictate their use.

3.4 PLACEING

The launching apron is usually placed on grade i.e., at bed level in horizontal position in alluvial soils, saving thereby costly excavation below bed level. It is, however, safer to provide the launching apron at a depth equal to its thickness below bed level.

The mesh used for wire-crates may have 4"x4" to 8"x8" openings and may be either factory woven (single or double twist) or hand woven at site with double twist. Generally 6"x6" mesh using 8-SWG galvanized wire is provided. The size of crates shall not exceed 30', in length, 10' in width and 6.5' in thickness. G.I. mesh partition walls (diaphragms) should be provided within a gabion, spaced not greater than the width of the box, but not less than 3 ft. apart.

In gravely river beds, it is customary to provide the wire-crated stone launching apron in the finally expected launching position. This arrangement is important because the settlement/launching of an apron placed horizontally in such strata can be uneven, leaving the gabion in a hanging position or badly damaged, making it altogether ineffective.

In more severe conditions where very high velocities are encountered, it is advisable to fix vertical tie wires (see Fig. 4) in the wire-crated stone (gabions) apron.

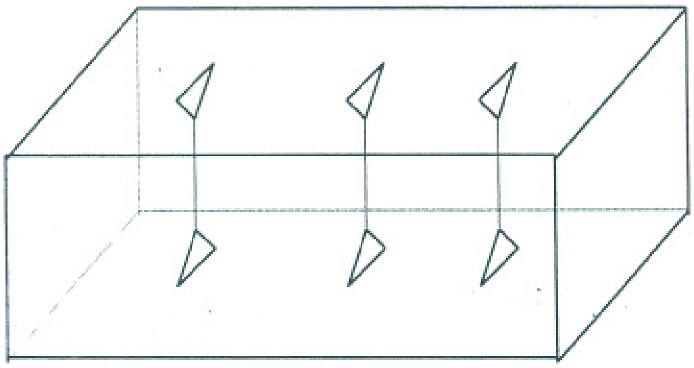
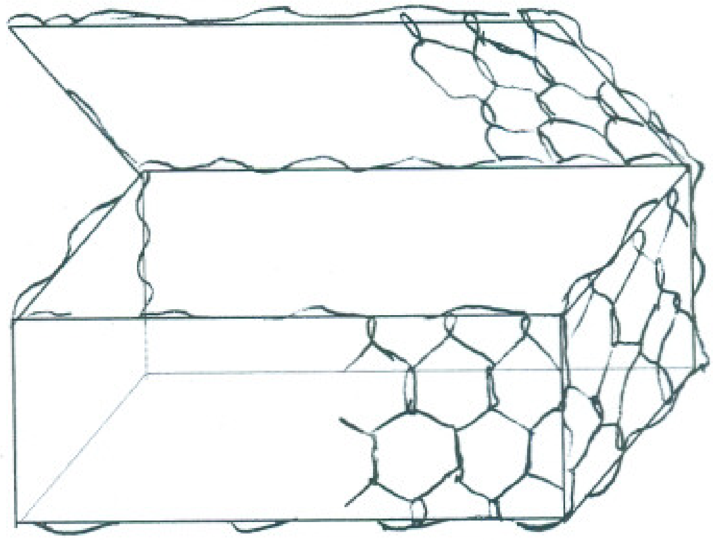


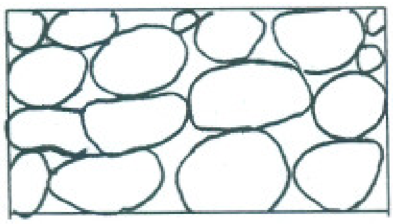
Figure 4: Vertical ties.

The following are the general guidelines for construction of gabions.

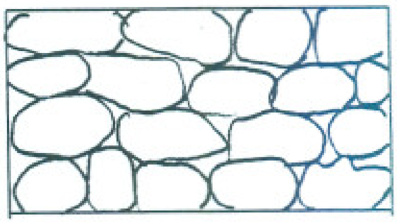
- The size of stone used for filling wire crates should always be 1.5 times the mesh opening of the gabion and not less than 9" in any case.
- The stone should be sound, hard and durable. It should not be elongated. The specified density is 130-165 pounds/cft.
- The crate should be constructed in the from of a rectangular box, filled with stone by hand packing and sewed properly with G.I wire of the same quality as that of mesh (see Fig. 5). The crates should be independent boxes.
- It is preferable to always provide vertical ties at a grid of 3'x3' (see Fig. 4).
- The adjacent crates should be securely jointed with the help of G.I. wire.



(a): Gabion Box with top side open.



(b) Wrongly filled Gabion



(c) Correctly filled Gabion.

Figure 5: Stone filing in Gabions.

The G.I wire should conform to the specifications of a particular work. In absence thereof the following should be observed:

i) The wire should be 8 SWG.

ii) The wire should not be brittle/hard (should not break on repeated bending).

iii) The wire should have visible coating of zinc.

iv) On repeated bending, the Zinc layer should not flake off the wire.

v) The wire should not be shining in look. Best color is dull-bluish-gray.

vi) The wire should be kept embedded in moist soil for 15 days to check for rusting.

vii) While purchasing G.I. Wire, 5 years guarantee against rusting should be obtained from manufacturer/supplier.

4. SUMMARY OF FORMULAE

For the convenience of the reader, all the formaluas used in the design of slope protection and launching aprons are summerized here.

4.1 SLOPE PROTECTION

List of Variables:

h_w	=	Height of wave in meters	**H**	=	Free Board in meters
V	=	Wind velocity in Km/hour (Typical value 120 Km/h)	T_s	=	Thickness of stone pitching in meters
F	=	Fetch in Kms	**Q**	=	Total discharge in cumec

4.1.1 Free Board

Free Board, H, is the maximum value determined from the following equations.

$h_w = 0.032\,(V \times F)^{1/2} + 0.763 - 0.271\,(F)^{1/4}$	[for F<32 Km]	(Eqn. 1)
$H = 1.5 \times h_w$	[H ≥ 1 m or 3']	(Eqn. 2)
H = as determined from Table-1		

4.1.2 Thickness of Stone Pitching

Thickness of Stone Pitching, T, is the maximum value determined from the following.

$T_s = 0.06\,Q^{1/3}$	($T_s \geq 0.61$ m)	(Eqn. 3)

4.2 STONE APRONS

List of Variables:

R	=	Normal Depth of Scour from H.F.L. in Ft	V_{av}	=	Average Velocity (fps)
			d_s	=	Mean diameter of stone used in apron in Ft. (also from Fig. 4)
q	=	Unit Discharge (Cusec/Ft)			
f	=	Lacey's silt factor (Table-2) or $f = 1.76\sqrt{d_{mm}}$	**t**	=	Thickness of launched apron (Ft)
			S	=	Subsurface slope (launched): S:1
y	=	Minimum depth of flow (Ft)	***l***	=	Length of launched apron (Ft)
x	=	Factor of Safety (Table-3)	**T**	=	Thickness of apron on grade (Ft)
D	=	Scour Depth from bed level (Ft)	**L**	=	Width of apron (Ft)

4.2.1 Scour Depth

Scour depth, D, is determined with help of the following equations.

$R = 0.9 \left(\frac{q^2}{f}\right)^{1/3}$		(Eqn. 4)
y = H.F.L - N.S.L	(or H.F.L - Bed Level)	
D = x R - y		(Eqn. 5)

4.2.2 Apron Dimensions

Width (L), thickness (T), and volume of the Launching Apron are determined from the following equations.

$d_s = 0.0126 (V_{av})^2$		(Eqn. 7)
$t = 1.5 \times d_s$	$1.25' \le t \le 4.5'$ for gabion apron (slanting) $2.0' \le t \le 4.5'$ for loose stone apron (slanting)	(Eqn. 8)
$l = \sqrt{S^2 + 1} \times D$	For slanting apron	(Eqn. 9)
Volume = $l \times t$		(Eqn. 10)
$L = 1.5 \times D$ or $L = l \div 1.5$	For at grade apron	(Eqn. 11) (Eqn. 11-a)
T = Volume/L or $T = 1.5 \times t$	$2.0' \le T \le 6.5'$ for gabion (at grade). $3.0' \le T \le 6.5'$ for loose stone apron (at grade).	(Eqn. 12) (Eqn. 12-a)

4.2.3 Type of Launching Apron

For velocities up to 5 fps	Provide loose stone apron.
For velocities between 6 and 10 fps	May provide loose or wire-crated stone apron.
For velocities Exceeding 10 fps	Provide wire-crated stone apron.

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GPS- THE TOOL OF THE SPACE AGE

A. W. Mir

1. Introduction

GPS, Global Positioning System, as the name suggests is the technology for position fixation of points, it could be on the surface of the earth or in the air. It is the technology which has made it possible to make high accuracy spatial data easier to acquire in far less time than ever possible before through the conventional geodetic surveying techniques. It is the off shoot of the US Government's Space Research Program and the System was developed for the World Wide Navigation purposes for US Armed Forces. It has been used as a surveying tool with immense utility in all disciplines of survey, mapping and remote sensing (i.e. photogrammetry), deformation monitoring and GIS (Geographical Information System) field data collection etc.

2. Basic Concept

Generally the satellite positioning refers to the American Satellites Timing And Ranging Global Positioning System i.e. NAVSTAR GPS. The basic concept is the three points resection using distances from the known to the unknown point, it can be best explained through the example of position fixation in two dimensions. Position of a lamp post in the street is to be fixed with reference to the two building corners (Figure No. 1). Distance measurement is made from one building corner to the lamp post, as D1. The post lies on the circle drawn with center at the building corner to the lamp post and draw another circle with radius D2 and center being the second building corner. The two circles intersect at two points and give two locations for the lamp post. This does not resolve the position fixation problem, so if we have third measurement and draw a third circle we will get one and only one location for the lamp post which will be the true location.

Now coming to the three dimensional position fixation using GPS. If the position of one satellite is known in outer space and distance from the receiver to the satellite is measured then the receiver lies somewhere on the sphere with satellite as its center and the measured distances being the radius of the sphere Figure No.2. if we have measured simultaneously distances from two satellites then the receiver lies somewhere on the circle created by the intersection of the two spheres. With two satellites we have reduced the location of the receiver from somewhere on the surface of the sphere to somewhere on the circumference of a circle. The position can be further reduced to two points on the circle if we introduce distance from third satellite. The correct position can be identified by comparing with the approximate position of the receiver. To have three dimensional fix a forth satellite is essential.

3. Distance Measurement from the Satellite

In its simplest form the time delay (dt) is multiplied by the velocity of light to get the range value (Figure No.3.) The velocity of light is very

General Manager (S&M) NESPAK, Lahore.

large number i.e. 299,792,458 m/s, a small error in time delay will introduce a large error in distance e.g. a clock accurate to one millionth of a second will cause an error of 300 meters. The satellites have therefore extremely accurate atomic clocks on board whereas the receiver has normally less accurate clock because of the high cost of atomic clocks, inconvenient to use and impractical in the field operations. The solution lies in synchronization of all clocks to the timing system managed by the US Navy Observatory called the GPS time. The accurate satellite and receiver clock offsets from GPS time have to be accurately known before proper corrections can be applied to each clock accordingly, (Figure No.4).

The GPS is the process of continuous coordination between the ground station, space satellites and the GPS user, (Figure No .5).

3.1 Ground/ Control Station

The component comprises one master control station located at Colorado Springs (USA); three transmission stations at Ascension Island in the South Pacific, Diego Island in the Indian Ocean and Kwajalein the North Pacific Ocean; and five monitor stations - four of which are co-located with the master control station and the transmission stations-and one located at Hawaii.

The position of the monitor station are accurately known and each has GPS receivers installed to enable each station to continuously monitor and receive signals from the satellites in view. The data along with the meteorological data is sent to the master control station, where the predicted satellite orbit (satellite ephemerides), satellites' health status and clock errors, and ionospheric correction parameters are determined to form an important part of the navigation message.This message is then sent to the transmission stations for further passage to every satellite, where it will be broadcast to GPS users worldwide, (Figure No.6)

3.2 Space Satellites

Satellites continuously transmit/ broadcast measurement signals and navigation messages to GPS users where ever they may be i.e. on earth surface or up in the air in an aircraft or in air balloon etc. There are at present 21 operational satellites and three additional operational satellites as standby or spares, this makes the constellation of 24 satellites positioned at the height of about 20,200 Km above the earth's surface orbiting around the earth approximately every 12 hours. The spare satellites can be positioned as replacement as and when an operational satellite do not function proprely. The satellites are arranged in six orbital planes of four satellites each, the planes are 60 degrees apart in longitude and inclined at an angle of 55 degree to the equatorial plane. The planes are numbered A through to F and the four satellites in a plane are numbered from 1 to 4, hence the orbiting satellites can be identified by the configuration number A1, B3 etc, (figure 7).

The Course/ Acquisition code (C/A code) is modulated onto the L1 carrier signal which has wavelength of about 300 m. The precise code (P-code) and satellite messages are superimposed onto both L1 and L2 carriers. The wavelength of L2 is about 30m. The C/A and P-code are also known as Standard Positioning Service (GPS) code and Precise Positioning Service (PPS) code respectively. Each satellite continuously transmits two L-band carrier (sinusoidal wave) signals. The wave length of L1 signal is about 19 cm and that of L2 about 24 cm. They also act as mediums to transport C/A and P-code sequences and navigation messages to GPS users by way of signal modulation technique which can be described as the super-imposition of codes and messages on the carrier signals.

3.3 GPS User

There are two basic types of GPS users, namely military and civilians, and there are various types of GPS receiver in the market for a variety of uses, e.g. ocean going vessels and airborne platforms navigation, navigational aid for travel in the unmapped areas of the earth,applications in survey and allied disciplines etc. The price of the instrument varies with the type and its application,single frequency hand held navigational GPS cost around one thousand dollars whereas dual frequency geodetic accuracy GPS may cost something like fifty thousand dollars per set. The cheaper ones have dimple design, fewer channels to track the satellites, and lower positioning accuracy. Receivers for GIS applications are normally single frequency type with five to ten meter positioning accuracy using a positioning technique called Differential GPS (DGPS). The receivers which have both C/A code and L1 phase data available, the positional accuracy can be substantially improved to sub-meter level by the DGPS technique.

With military secrecy considerations the US government has imposed restrictions on high accuracy instantaneous positioning using one receiver. One such restriction is the activation of Anti-Spoofing (AS) on satellites since January 1994. The result is that the P-code which is used to derive higher precision pseudo-range measurement data and to recover the L2 phase measurement is no longer available to GPS users because it is switched to Y-code which is only available to authorized users. However, some GPS receivers have found a way round this hurdle and they have the capability to switch automatically to another satellite tracking mode so that L2 phase measurements can be recovered when AS is on.

4. GPS Appplications

There are numerous applications, the basic ones being:

1. Navigation while travelling in open desert with few features

2. Navigation of air borne crafts, e.g. aircrafts, balloons, sea going vessels etc.

3. Survey and Mapping;

(a) establishment of geodetic survey control

(b) controlling flight lines of aircraft for taking aerial photography

(c) ground control for photogrammetric mapping

(d) survey control for topographic mapping via conventional method.

(e) reconnaissance survey in un-mapped or poorly mapped regions

(f) spatial data acquisition for GIS work

(g) deformation survey for tectonic movement studies.

Hare we shall mainly discuss briefly the Survey and Mapping applications of GPS.

(a) Establishment of Geodetic Survey Control (GSC)

Traditionally GSC have been established by triangulation stations being intervisible for angular measurements or later on through trilateration using long distance eletromagnetic distance measuring equipment and once again the stations had to be intervisible. The stations were established from hill top to hill top involving lots of physical effort and time required to reach the station. The measurements were also subject to weather conditions being favourable.

The GPS fixations are free of the intervisibility and weather constraints. The only constraint is that the view to the sky should be clear i.e. 15 degree from the horizon.

(b) Controlling Flight Lines of Aircraft for taking Aerial Photography

The aircraft equipped and controlled by the GPS flight path guidance system flies on exact lines as planned thus reducing wastage due to repeat flying. Photography strips are straight as an arrow and eliminates gaps between the adjoining flight lines. With the camera position known at the time of exposure the need for ground control for photogrammetric mapping is reduced.

(c) Ground Control for Photogrammetric Mapping

This activity via the conventional methods involves levelling for vertical control and triangulation or traversing etc. for horizontal control, both these activites are time consuming with GPS the fixation of ground control is much faster and involves minimum of manpower, there is none of the long lines of levelling, triangulation or traversing required.

(d) Survey Control for Topographic Mapping via Conventional Methods.

Ground control is essential prerequisite for any topographic survey, e.g. topographic surveys for engineering projects (airports, barrages, dams, or large industrial complexes etc.), roads, highways and motorways, canals, railways, transmission lines above ground or buried etc. Bringing in national grid control from a long distance away is expensive and time consuming activity whereas with GPS the control can be established at site with lesser cost and in fraction of the time compared to the conventional methods of ground control.

(e) Reconnaissance Survey in Un-mapped or Poorly Mapped Regions

This activity in the past involved lot of approximation and in some cases amounted to wandering in the dark but with the hand held GPS the uncertainty of the past is no more there and people can not get lost in the deserts or other similar featureless polar regions of the world.

(f) Spatial Data Collection for GIS Work

Single frequency hand held or back pack mounted type GPS are most economical and convenient to use for GIS field data collection.

g. Deformation Survey for Tectonic or Earth Quake Prediction Studies.

This activity requires accurate measurements in real-time on continuous basis to keep track of the earth's behaviour and to be able to fore warn and take remedial measures like the evacuation of population from the earth quake zone. GPS has made such measurements possible on remote control basis. The recent examples are in Wellington New Zealand and in Indonesia.

Another excellent example is the refixation of Mount Everest in 1992 simultaneously from Nepal and Chinese side.

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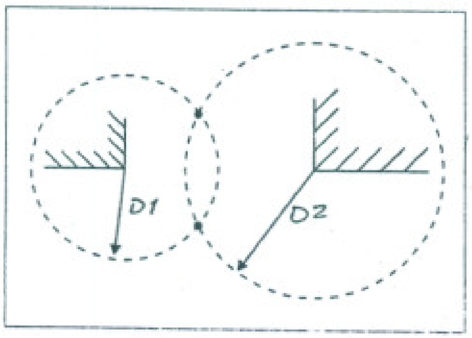


Figure No.1

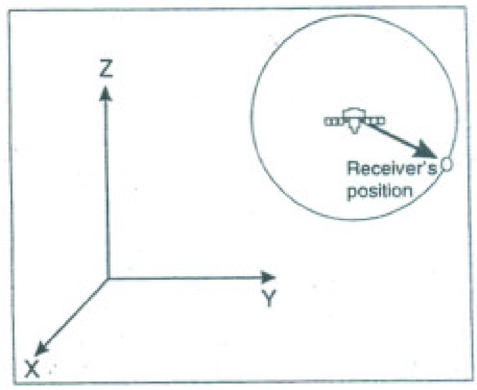
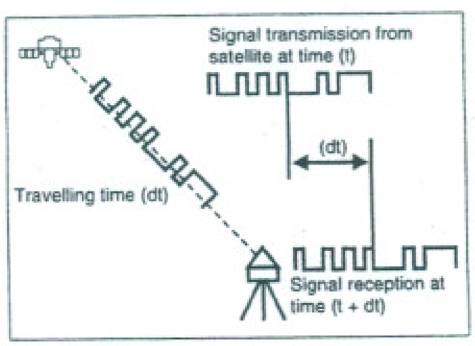


Figure No.2



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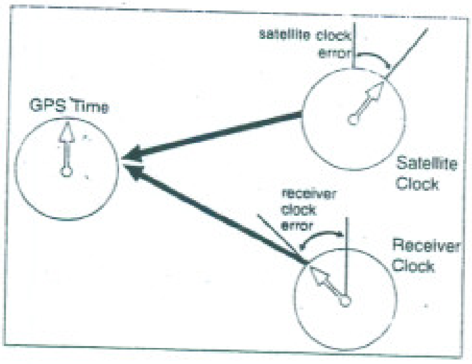

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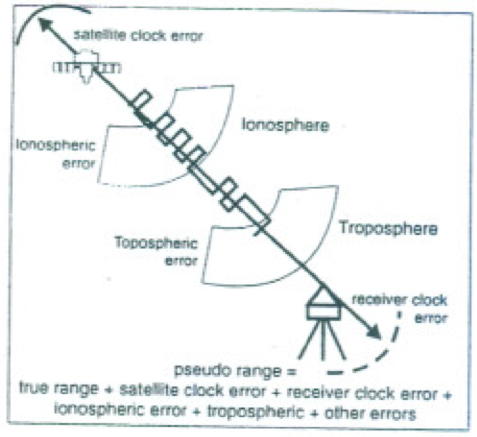

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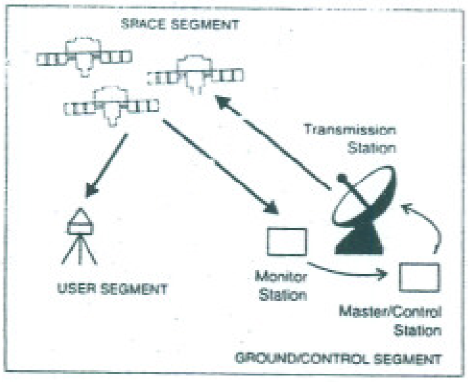

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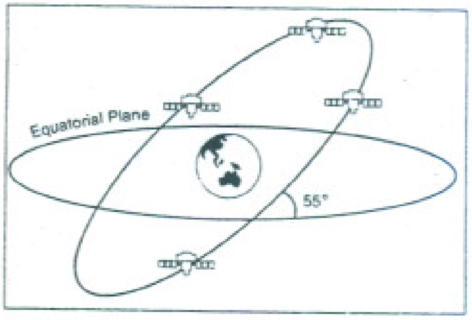

Figure No.7

specimen was coated with a water proofing chemical. The mortar joint provided between the pair of brick consisted of different types of blends of OPC-Pozzolana with chemical admixture. The test specimens were placed in such a way that the lower half brick was remained dipped in water. Assent of water would take place through capillary action. The brick pairs were kept in different water containers possessing various salt proportions as mentioned above. The Nicle Choloride ($NiCl_2$) in 0.1% ratio was also added to each container. the use of $NiCl_2$ was just to assess the penetration of ions through bricks upto the surface. The upper most surface of the brick of each pair was treated with Dimethyle glyozime (D.M.G.). When the Ni^{++} ions come to the surface, penetrating through brick structure, a compex of Ni $(D.M.G.)_2$ would impart rose red colour to the surface that was a proof of SO_4^{++} and Ni^{++}ions to penetrate upto top level.

The different types of mortar joints prepared with OPC-Chemicals and OPC-mineral admixtures, were used to observe the resistance of blends. The chemical admixtures were water repellent in nature, while mineral admixture consists of pozzolanic materials with high soluble Silica (SiO_2) contents (in amorphous state). The results regarding resistivity are provided in Table-2

The results were consisted of the extent of resistance for specific time periods by the mortar joints, worked as obstacle in the penetration of water and SO_4 $^{++}$ions. The mortar joints were prepared by the following combinations:-

1) Ordinary Portland Cement (OPC).
2) OPC + 0.1% Calcium Stearate.
3) OPC + 0.1% Polyvinyl acetate.
4) OPC + 0.1% Wax emulsion.
5) OPC + 0.1% Bitumen Emulsion.
6) OPC + 0.1% Soap solution.
7) OPC + 0.1% Waste mobile oil.
8) OPC + 0.1% Ammonium Stearate.
9) OPC + 0.1% weather sheild.
10) OPC - Slage (30%) + 0.1% Calcium Stearate.
11) OPC - Slage (30%) + 0.1% Polyvinyl acetate.
12) OPC - Slage (30%) + 0.1% Wax Emulsion.
13) OPC - Slage (30%) + 0.1% bitumen Emulsion.
14) OPC - Slage (30%) + 0.1% Soap Solution.
15) OPC - Slage (30%) + 0.1% Waste mobile oil.
16) OPC - Slage (30%) + 0.1% Amonimum Stearate.
17) OPC - Slag (30%) + 0.1% weather sheild.
18) OPC - RHA (30%) + 0.1% Calcium Stearate.
19) OPC - RHA (30%) + 0.1% Polyvinyl acetate.
20) OPC - RHA (30%) + 0.1% Wax Emulsion.
21) OPC - RHA (30%) + 0.1% bitumen Emulsion.
22) OPC - RHA (30%) + 0.1% Soap Solution.

23) OPC - RHA (30%) + 0.1% Waste mobile oil.

24) OPC - RHA (30%) + 0.1% Amonimum Stearate.

25) OPC - RHA (30%) + 0.1% weather sheild.

26) OPC - PFA (30%) + 0.1% Calcium Stearate.

27) OPC - PFA (30%) + 0.1% Polyvinyl acetate.

28) OPC - PFA (30%) + 0.1% Wax Emulsion.

29) OPC - PFA (30%) + 0.1% bitumen Emulsion.

30) OPC - PFA (30%) + 0.1% Soap Solution.

31) OPC - PFA (30%) + 0.1% Waste mobile oil.

32) OPC - PFA (30%) + 0.1% Amonimum Stearate.

33) OPC - PFA (30%) + 0.1% weather sheild.

34) OPC - B. Clay (30%) + 0.1% Calcium Stearate.

35) OPC - B. Clay (30%) + 0.1% Polyvinyl acetate.

36) OPC - B. Clay (30%) + 0.1% Wax Emulsion.

37) OPC - B. Clay (30%) + 0.1% bitumen Emulsion.

38) OPC - B. Clay (30%) + 0.1% Soap Solution.

39) OPC - B. Clay (30%) + 0.1% Waste mobile oil.

40) OPC - B. Clay (30%) + 0.1% Amonimum Stearate.

41) OPC - B. Clay (30%) + 0.1% weather sheild.

The repellent behaviour of each type of mortar joint has been summarized up as discussed earlier (in table No.2). The period was expressed in months.

3. DISCUSSION

From the practical data available during the study on salt attack on bricks reflected. that Sulphate of soduim is too harmful. The cronic effects of Na_2SO_4 interaction makes the structure unsafe, unstable and less durable as compared to its life assessment in normal conditions.

Table-1 enables us to understand the corrosive characteristic of Na_2SO_4. The bricks under observation were soaked in distilled water, solution of 0.1% Na_2SO_4, 0.1% $NaNO_3$, 0.1% Na_2CO_3 and 0.1% $CaCl_2$. The compressive strength was evaluated at the periods 3 and 6 months, 1 year, 3 years, 6 years, 9 years and 10 years. The compressive strength of each series of bricks dipped in various types of salts solutions directly provides the effect of such salts on durability of bricks. It could be assessed from the results from table No.1 that only solution of 0.1% Na_2SO_4 proved to be horribly harmful. The fig.II shows that the compressive strength of the brick treated in 0.1% Na_2SO_4 was decreased to 300 psi from 2200 psi. The other sets of bricks treated with other salt solutions preserved their compressive strength almost the same.

Results in table No.2 reflects that the chemical admixtures coated on the brick are partially failed in the presence of mortar joint prepared from OPC. However, the mortar joints made of OPC + pozzolanic admixture show better resistance to water penetration. The

satellite continuously transmits two L-band carrier (sinusoidal wave) signals. The wave length of L1 signal is about 19 cm and that of L2 about 24 cm. They also act as mediums to transport C/A and P-code sequences and navigation messages to GPS users by way of signal modulation technique which can be described as the super-imposition of codes and messages on the carrier signals.

3.3 GPS User

There are two basic types of GPS users, namely military and civilians, and there are various types of GPS receiver in the market for a variety of uses, e.g. ocean going vessels and airborne platforms navigation, navigational aid for travel in the unmapped areas of the earth,applications in survey and allied disciplines etc. The price of the instrument varies with the type and its application,single frequency hand held navigational GPS cost around one thousand dollars whereas dual frequency geodetic accuracy GPS may cost something like fifty thousand dollars per set. The cheaper ones have dimple design, fewer channels to track the satellites, and lower positioning accuracy. Receivers for GIS applications are normally single frequency type with five to ten meter positioning accuracy using a positioning technique called Differential GPS (DGPS). The receivers which have both C/A code and L1 phase data available, the positional accuracy can be substantially improved to sub-meter level by the DGPS technique.

With military secrecy considerations the US government has imposed restrictions on high accuracy instantaneous positioning using one receiver. One such restriction is the activation of Anti-Spoofing (AS) on satellites since January 1994. The result is that the P-code which is used to derive higher precision pseudo-range measurement data and to recover the L2 phase measurement is no longer available to GPS users because it is switched to Y-code which is only available to authorized users. However, some GPS receivers have found a way round this hurdle and they have the capability to switch automatically to another satellite tracking mode so that L2 phase measurements can be recovered when AS is on.

4. GPS Appplications

There are numerous applications, the basic ones being:

1. Navigation while travelling in open desert with few features
2. Navigation of air borne crafts, e.g. aircrafts, balloons, sea going vessels etc.
3. Survey and Mapping;

(a) establishment of geodetic survey control

(b) controlling flight lines of aircraft for taking aerial photography

(c) ground control for photogrammetric mapping

(d) survey control for topographic mapping via conventional method.

(e) reconnaissance survey in un-mapped or poorly mapped regions

(f) spatial data acquisition for GIS work

(g) deformation survey for tectonic movement studies.

Hare we shall mainly discuss briefly the Survey and Mapping applications of GPS.

(a) Establishment of Geodetic Survey Control (GSC)

Traditionally GSC have been established by triangulation stations being intervisible for angular measurements or later on through trilateration using long distance eletromagnetic distance measuring equipment and once again the stations had to be intervisible. The stations were established from hill top to hill top involving lots of physical effort and time required to reach the station. The measurements were also subject to weather conditions being favourable.

The GPS fixations are free of the intervisibility and weather constraints. The only constraint is that the view to the sky should be clear i.e. 15 degree from the horizon.

(b) Controlling Flight Lines of Aircraft for taking Aerial Photography

The aircraft equipped and controlled by the GPS flight path guidance system flies on exact lines as planned thus reducing wastage due to repeat flying. Photography strips are straight as an arrow and eliminates gaps between the adjoining flight lines. With the camera position known at the time of exposure the need for ground control for photogrammetric mapping is reduced.

(c) Ground Control for Photogrammetric Mapping

This activity via the conventional methods involves levelling for vertical control and triangulation or traversing etc. for horizontal control, both these activites are time consuming with GPS the fixation of ground control is much faster and involves minimum of manpower, there is none of the long lines of levelling, triangulation or traversing required.

(d) Survey Control for Topographic Mapping via Conventional Methods.

Ground control is essential prerequisite for any topographic survey, e.g. topographic surveys for engineering projects (airports, barrages, dams, or large industrial complexes etc.), roads, highways and motorways, canals, railways, transmission lines above ground or buried etc. Bringing in national grid control from a long distance away is expensive and time consuming activity whereas with GPS the control can be established at site with lesser cost and in fraction of the time compared to the conventional methods of ground control.

(e) Reconnaissance Survey in Un-mapped or Poorly Mapped Regions

This activity in the past involved lot of approximation and in some cases amounted to wandering in the dark but with the hand held GPS the uncertainty of the past is no more there and people can not get lost in the deserts or other similar featureless polar regions of the world.

(f) Spatial Data Collection for GIS Work

Single frequency hand held or back pack mounted type GPS are most economical and convenient to use for GIS field data collection.

g. Deformation Survey for Tectonic or Earth Quake Prediction Studies.

This activity requires accurate measurements in real-time on continuous basis to keep track of the earth's behaviour and to be able to fore warn and take remedial measures like the evacuation of population from the earth quake zone. GPS has made such measurements possible on remote control basis. The recent examples are in Wellington New Zealand and in Indonesia.

Another excellent example is the refixation of Mount Everest in 1992 simultaneously from Nepal and Chinese side.

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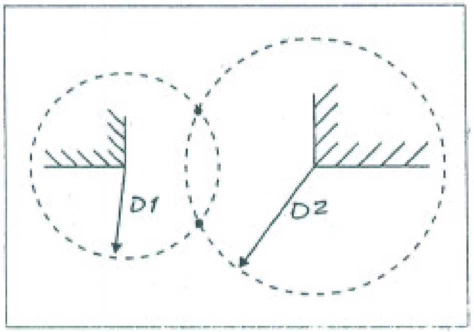


Figure No.1

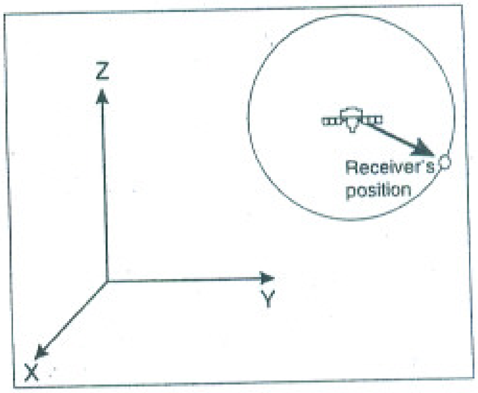
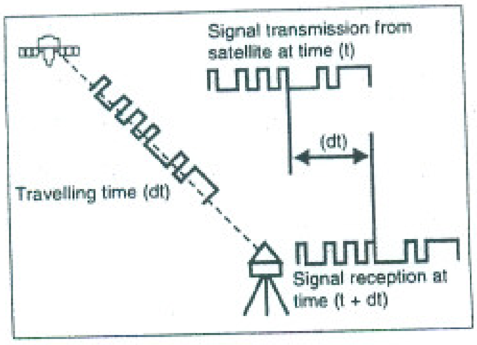


Figure No.2



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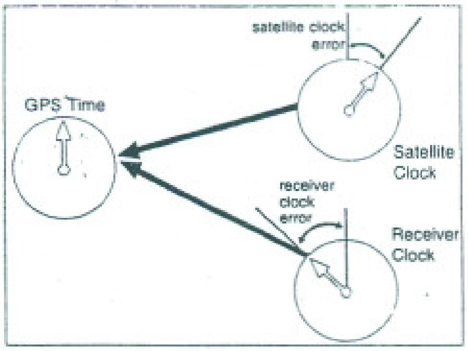

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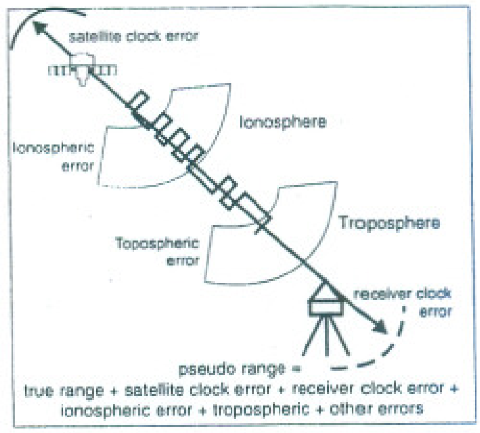

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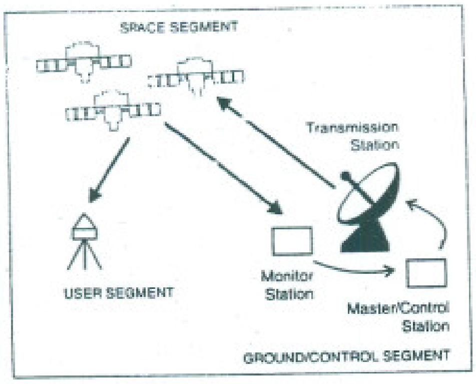

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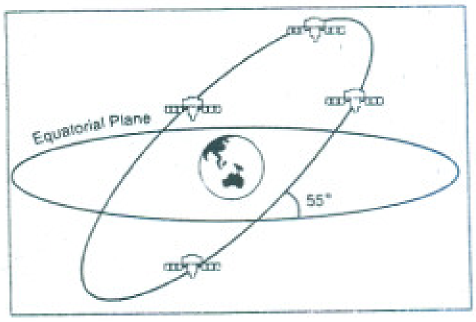

Figure No.7

SULPHATE ACTION ON BRICK MASONRY

Rana Nisar Ahmad*
Dr. Professor Muhammad Zafar Iqbal**
Engr. Muhammad Naeem Chughtai***

Abstract

Brick is a lattice unit of building construction. It determines the durability of a structure. The low compressive strength bricks create the detrimental Characteristic in structure. The durability of Bricks is also effected by the salt action. A ten years based study on bricks was performed on salt attack especially action of sodium sulphate (Na_2SO_4 $2H_2O$) was observed. The effects were observed periodically. The compressive strength of sulphate effected bricks was determined repeatedly and found that the sulphate effected bricks lost their fractural strength to miserable extent. The indirect remedy was suggested by providing masonry joints mixed with chemical, agri-based and mineral admixtures. Such a blend for mortar joints prohibited the penetration of sulphate ions.

Study included, filling of masonry joints with cement-mortar mixes prepared with OPC-Pozzolanic blend (70:30) and chemical based admixtures. These included calcium stearate, Polyvinyle-acetate, Wax Emulsion, Bitumen Emulsion, Soap solution, Waste Mobile Oil, Ammonium Stearate and Weather sheild in the ratio of 0.1% of the mortar by weight. It was observed that ordinary portland cement was attacked by SO_4 after 3 months and salts were visible on the surfaces. In case of OPC-pozzlanic blend mixed with 0.1% of calcium stearate, Poly-vinylacetate, Wax Emulsion, Bitument Emulsion, Soap solution, Waste Mobile Oil, Ammonium Stearate and Weather Sheild resistance was observed ranged from 16 months to 77 months meaning that the later prohibited the efflorcence to the extent of more than four times.

Introduction

White spots of salts accumulations can be seen on the masonry brick work. The white accumulation is commonly consisted of the different types of salts. When soluble salts dissolved in water, reaches in the vicinity of masonry work, the rising up of solution takes place. The capillary action plays an important role in the upward movement of water alongwith soluble salts. When the bricks are dense, salts solutions are drawn by strong capillary action. These capillary forces have the tendency to draw the solution near the surface exposed to air. On the other hand when the pores of bricks are of bigger size, the solution containing salt will not come out of the bricks due to the weak capillary forces, so evaporation due

* Deputy Director-I, Building Research Station, Lahore.
** Director, Institute of Chemistry, Punjab University, New Campus, Lahore.
*** Director, Building Research Station, Lahore.

to diffusion on pore ventilation takes place and resultantly crystallization of salts takes place within the brick surface, called cryptoflorescence. When the solution comes out to atmosphere, it is evaporated by the solar heat energy and the dissolved salts become deposited on the surface, known as efflorescence.

2. Experimental Work

The study was conducted at Building Research Station, Lahore. The experiment consisted of two stages. At first stage, affects of injurious salts had been examined directly by dipping the bare bricks in different media containing distalled water, solution of 0.1% Sodium Sulphate (Na_2SO_4), solution of 0.1% Sodum Chloride ($NaCl$), solution of 0.1% Sodium Niterate (Na_2NO_3) and solution of 0.1% Calcium Chloride ($CaCl_2$). The bricks were kept remained in the above mentioned solutions and the effect of various salts was observed. The compressive strength of bricks from each type of medium had been determined at the age of 3 and 6 months, 1 year, 3 years, 6 years, 9 years and 10 years. The test results achieved in this respect are provided in Table No.1.

Salt of Sodium Sulphate was fond hazerdous to brick structure. For the second stage study, different containers were taken. The containers were provided with different mixes. Sodium Sulphate (Na_2SO_4) ranging from 0.1% to 0.3% in tap water, wet soil, dry soil, wet sand and dry sand. Two containers of each above combinations were prepared. One container of each identical set was kept free from Sodium Sulphate (Na_2SO_4) and other was impregnated with Sodium Sulphate (Na_2SO_4). The detail of containers and mixes are given as under:-

Sr. No.	Description of media	%age of Na_2SO_4 mixed in various containers		
		1	2	3
1	Tap water taken in container	-	-	-
2	Tap water taken in container	0.1	0.2	0.3
3	Wet soil (mixed with 25% H_2O) in container	-	-	-
4	Wet soil (mixed with 25% H_2O) in container.	0.1	0.2	0.3
5	Dry soil taken in container	-	-	-
6	Dry soil taken in container	0.1	0.2	0.3
7	Sand with 25% water in container	-	-	-
8	Sand with 25% water in container .	0.1	0.2	0.3

For this stage study the experiment was designed that a pair of bricks was joined by a single mortar joint (Fig.-1) in such a way that lower brick of the test specimen was coated with a water proofing chemical. The mortar joint provided between the pair of brick consisted of different types of blends of OPC-Pozzolana with chemical admixture. The test specimens were placed in such a way that the lower half brick was remained dipped in water. Assent of water would take place through capillary action. The brick pairs were kept in different water containers possessing various salt proportions as mentioned above. The Nicle Choloride ($NiCl_2$) in 0.1% ratio was also added to each container. the use of $NiCl_2$ was just to assess the penetration of ions through bricks upto the surface. The upper most surface of the brick of each pair was treated with Dimethyle glyozime (D.M.G.). When the Ni^{++} ions come to the surface, penetrating through brick structure, a compex of Ni $(D.M.G.)_2$ would impart rose red colour to the surface that was a proof of SO_4^{++} and Ni^{++}ions to penetrate upto top level.

The different types of mortar joints prepared with OPC-Chemicals and OPC-mineral admixtures, were used to observe the resistance of blends. The chemical admixtures were water repellent in nature, while mineral admixture consists of pozzolanic materials with high soluble Silica (SiO_2) contents (in amorphous state). The results regarding resistivity are provided in Table-2

The results were consisted of the extent of resistance for specific time periods by the mortar joints, worked as obstacle in the penetration of water and SO_4 $^{++}$ions. The mortar joints were prepared by the following combinations:-

1) Ordinary Portland Cement (OPC).
2) OPC + 0.1% Calcium Stearate.
3) OPC + 0.1% Polyvinyl acetate.
4) OPC + 0.1% Wax emulsion.
5) OPC + 0.1% Bitumen Emulsion.
6) OPC + 0.1% Soap solution.
7) OPC + 0.1% Waste mobile oil.
8) OPC + 0.1% Ammonium Stearate.
9) OPC + 0.1% weather sheild.
10) OPC - Slage (30%) + 0.1% Calcium Stearate.
11) OPC - Slage (30%) + 0.1% Polyvinyl acetate.
12) OPC - Slage (30%) + 0.1% Wax Emulsion.
13) OPC - Slage (30%) + 0.1% bitumen Emulsion.
14) OPC - Slage (30%) + 0.1% Soap Solution.
15) OPC - Slage (30%) + 0.1% Waste mobile oil.
16) OPC - Slage (30%) + 0.1% Amonimum Stearate.
17) OPC - Slag (30%) + 0.1% weather sheild.
18) OPC - RHA (30%) + 0.1% Calcium Stearate.
19) OPC - RHA (30%) + 0.1% Polyvinyl acetate.
20) OPC - RHA (30%) + 0.1% Wax Emulsion.
21) OPC - RHA (30%) + 0.1% bitumen Emulsion.
22) OPC - RHA (30%) + 0.1% Soap Solution.

23) OPC - RHA (30%) + 0.1% Waste mobile oil.

24) OPC - RHA (30%) + 0.1% Amonimum Stearate.

25) OPC - RHA (30%) + 0.1% weather sheild.

26) OPC - PFA (30%) + 0.1% Calcium Stearate.

27) OPC - PFA (30%) + 0.1% Polyvinyl acetate.

28) OPC - PFA (30%) + 0.1% Wax Emulsion.

29) OPC - PFA (30%) + 0.1% bitumen Emulsion.

30) OPC - PFA (30%) + 0.1% Soap Solution.

31) OPC - PFA (30%) + 0.1% Waste mobile oil.

32) OPC - PFA (30%) + 0.1% Amonimum Stearate.

33) OPC - PFA (30%) + 0.1% weather sheild.

34) OPC - B. Clay (30%) + 0.1% Calcium Stearate.

35) OPC - B. Clay (30%) + 0.1% Polyvinyl acetate.

36) OPC - B. Clay (30%) + 0.1% Wax Emulsion.

37) OPC - B. Clay (30%) + 0.1% bitumen Emulsion.

38) OPC - B. Clay (30%) + 0.1% Soap Solution.

39) OPC - B. Clay (30%) + 0.1% Waste mobile oil.

40) OPC - B. Clay (30%) + 0.1% Amonimum Stearate.

41) OPC - B. Clay (30%) + 0.1% weather sheild.

The repellent behaviour of each type of mortar joint has been summarized up as discussed earlier (in table No.2). The period was expressed in months.

3. DISCUSSION

From the practical data available during the study on salt attack on bricks reflected. that Sulphate of soduim is too harmful. The cronic effects of Na_2SO_4 interaction makes the structure unsafe, unstable and less durable as compared to its life assessment in normal conditions.

Table-1 enables us to understand the corrosive characteristic of Na_2SO_4. The bricks under observation were soaked in distilled water, solution of 0.1% Na_2SO_4, 0.1% $NaNO_3$, 0.1% Na_2CO_3 and 0.1% $CaCl_2$. The compressive strength was evaluated at the periods 3 and 6 months, 1 year, 3 years, 6 years, 9 years and 10 years. The compressive strength of each series of bricks dipped in various types of salts solutions directly provides the effact of such salts on durability of bricks. It could be assessed from the results from table No.1 that only solution of 0.1% Na_2SO_4 proved to be horribly harmful. The fig.II shows that the compressive strength of the brick treated in 0.1% Na_2SO_4 was decreased to 300 psi from 2200 psi. The other sets of bricks treated with other salt solutions preserved their compressive strength almost the same.

Results in table No.2 reflects that the chemical admixtures coated on the brick are partially failed in the presence of mortar joint prepared from OPC. However, the mortar joints made of OPC + pozzolanic admixture show better resistance to water penetration. The

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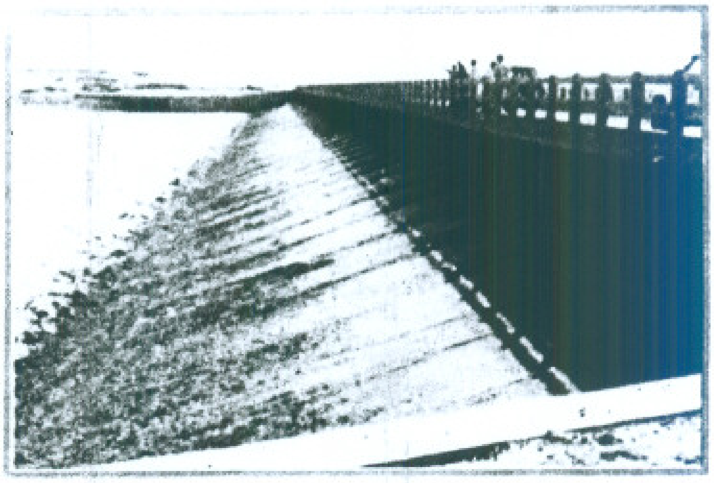

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