and thus establishing a cause for increase in prices with the oil producing developing countries.

3. Also considering the scenarios developed by experts in developed countries of rise in petroleum prices since 1973-74 and assuming that Iran Iraq war will not continue indefinitely and world not extend to completely damage their respective oil reserves the prices rise, at current rates, was taken at 20% which would correspond to the rate of inflation in price of capital goods and services produced and offered by the developed countries to the developing countries.

4. Three cost scenarios were prepared for petroleum crude and products needs :

Scenario (a) Assuming a yearly increase in price per bbl of market crude by 20% till 1986-87 and then declining to 10% increase till 1989-90. This scenario resumed that by middle of 1980 the developed countries would achieve the break through for being self-sufficient to a greater degree and also optamise use of renewable energy sources for their domestic consumption, and achieve its target of 15% reduction through demand management applications.

Scenario (b) Scenario b assumed the most favourable conditions where rate of inflation in developed countries would gradually declined alongwith their being more self-reliant then in the year 1980-81.

Scenario (c) Scenario c was considered most likely at that time accounting for the fact that Iran Iraq would not damage its petroleum crude reservoir nor the crude refining capacity and that both the production and the refining would be back in full swing by the end of 1984.

5. The net result of these three scenarios in term of billions of U.S, dollar to be spent on imports with 1.3 billion dollars in 1980-81, increasing to a range of 5.7 billion dollars, to 9.6 billion dollars, giving the lowest among the three scenarios at a value of 5.7 billion dollars under scenario b.

Natural Gas

1. The study indicated that the deficit would registered in 1982 and increase here-after in the next 10 years i.e. 1992. To ease the situation of deficit, considering the demand management aspects only, following recommendations were made by the secretariat of NEPC.

(a) Cement industry be given a lead time of 3 years to switch over to fuel oil or coal,

(b) Supply more gas for fertilizer industry at a rate of 40000 MMCFT per year for half a million per ton production of Urea Plant and to limit the gas consumption both for process and fuel to 44000 MMCFT in 1990.

(c) For power sector giving it a lead time of 4 to 5 years. The future increase in capacity to go on fuel oil and coal, thus freezing the supply the natural gas at a maximum of 100,000 MMCFT to the power sector.

(d) For other industries giving a lead time of 5 years the gas supply to be frozen at 48000 MMCFT and the industry to switch over to alternate fuels.

(e) In domestic and commercial sector atleast 300,000 tons reduction in consumption of kerosene oil, over period of 10 years, was to be achieved through improved appliances. Through this strategy the deficit in natural gas, assuming no substantive increase in its availability, would have appeared only in 1989 or 1990.

The overall recommendations for the energy policy in the next 10 years i.e. 1980-90 included :

(i) Decline in overall consumption growth rate of petroleum product, taking energy products consumption, from 6% in 1980 to 4.5 per year in 1990.

(ii) Inter-fuel substitution of petroleum and natural gas with indigenous sources like coal as the first priority and use of surplus furnace oil with coal as second priority.

(iii) Coal mining to be developed into regular industry for which the pricing policy should be announced by the Government in one year.

(iv) 10 years forecast should be revised every year for the 10 years period incorporating the factual needs in the forecast which should constitute guide lines for the formation of the next 5 years plan.

(v) As the development of renewable sources of energy should be rapidly developed to promote its use as a substitute to kerosene oil and diesel oil and supplement electricity demand through a decentralized management basis for the villages which are small and remote and are not eligible for hooking up to the national grid because of the economic reasons.

Pakistan Engineering Council was commissioned to develop a study on energy options for Pakistan in 1982. The assignment was given by the President while in-

augurating 5th annual convention of the council. The committee constituted made useful recommendations some of which I would mention :

(a) The peak demand in 1986 requiring capacity of 5300 mw was to reach 20,000 mw by the year 2000. The study proposed installation of coal fired power station of 1000 mw at Pipri to be developed on a modular approach with each modular being 200 mw. In addition to 1000 mw thermal power generation system at Jam Shoro by 1988. It included establishment of 300 mw station at Lakhra coal and a chain of nuclear electric units in the country; the first of which was stated to be 900 mw at Chashma. It also mentioned the role of the renewable sources of energy including ocean i.e. OETC and others.

(b) It suggested convertion of existing gas turbines to combined cycle power system. By commissioning 33 gas turbines with WAPDA and KESC to combined cycle power system, the report states that the efficiency could increase from 28 to 42% thus giving an additional 125 mw over its existing capacity of 646 mw at Faisalabad and Karachi.

(c) It also suggested that through use of re-generators on gas turbines 30% of fuels could be saved.

(d) On transmission losses installation of shunt capacitors were suggested.

Its recommendation amounted to inter-fuel substitution with indigenous resources in power generation and debottlenecking of the transmission system. The other recommendations were the same as already stated earlier.

On the administrative side also it agreed with the administrative improvement that have already been stated earlier, with additional proposal of using existing institutions as post graduate studies center for engineering.

Concludings

I would propose following options for consideration of this body of engineers :

(a) There is a need for complete involvement of experts in Government decision making, in policy making, in the sector of energy. Most of the decisions taken reflect ignorance of technical and operational efficiencies.

(b) Financial resources contains is a major bottlenecking in accelerating development of increase in energy supply and of energy management. Towards this end a drastic change in present pricing policy is needed.

The pricing policy needs to minimize the control of the Government on it and give the pricing of energy products a flexibility which is expected under a free market economy with prices being overseen by the Government.

(c) Future increases in power generation should be decentralized and that the distribution net work should cater the enonomic areas around each production source. This shall save the enormous cost of extension of national grid which travels over miles of areas where consumption of electricity is not foreseen.

(d) The nuclear energy development has to be paced more rapidly to fill the enlarging gap on availability of electricity for different economic sectoral consumption.

(e) With the success and the break through having been achieved on certain renewable energy resources, the optamization of its use in the residential sector appears most essential to reduce the demand both on the national grid and on the fossil fuels.

(f) The distribution of consumer products of petroleum must improve to ensure that the retailor does not charge a price over and above the maximum unit price fixed by the Government.

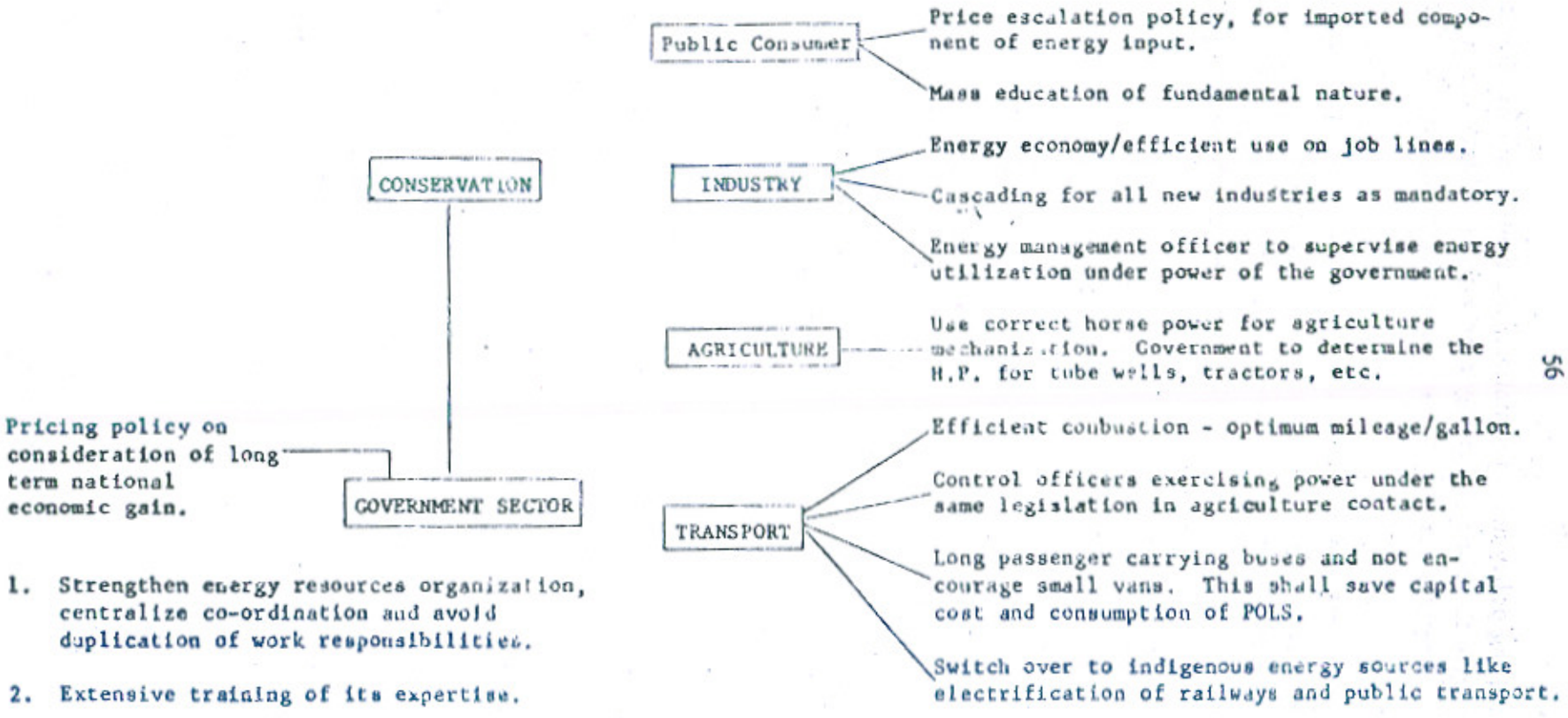
(g) Energy conservation management ordinance which presently is confined to all primary sources other than hydel should be enforced before end of 1985.

(h) Applied Research facilities to test equipment used in national grid work extension and up-gradation of the high tension laboratory is most essential to achieve higher generation efficiencies and distribution management.

(i) De-centeralized controls of energy supply with central monitoring using computors is needed. A beginning in the direction has already been made.

(j) Use of foreign consultants have become a disease. This infection must be eradicated and expertise in the country must have priority in energy sector development including planning.

ENERGY CONSERVATION PLAN.



1. Strengthen energy resources organization, centralize co-ordination and avoid duplication of work responsibilities.
2. Extensive training of its expertise.
3. Extensive utilization of techuical assistance.
4. Avoid creation of too many energy departments since it creates co-ordination and communication problems.

Employing Waste Stabilization Ponds for Low Cost Sanitation in Pakistan

by
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Dr. Khurshed Ahmed

Abstract

Investigations for the treatment of wastewater was carried out in Lahore (Pakistan) on four rectangular Waste Stabilization Ponds. With parallel operation, ponds gave their maximum performance at an organic loading of 300 lbs BOD/A/D. Maximum bacterial removal efficiencies were also obtained with series operation. Ponds were found to be equally good in removing nutrients etc. Ponds at the given loadings emitted odour only during hot summer months. Presence of various algal species and microscopic organisms were related to organic loadings and depth. With proper maintenance of pond likes mosquitos and flies breeding can be kept to a minimum.

Introduction

Waste stabilization ponds are considered most suitable for developing countries, they are simple to construct, easy to maintain, use very little imported material and have little power requirement. The effluent is relatively good and a high mortality of bacteria is obtained. A major disadvantage of this kind of system is the large land area requirements associated with ponds.

In view of this four experimental facility was constructed in Lahore to investi-

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problems.

gate the performance under local conditions in terms of the effluent quality under different loading rates and process configuration. It was envisages that this study would be of help in suggesting the feasibility of the ponds for Lahore and other countries situated in semi-arid region and indicate optimum loading range for their economic use.

Waste stabilization ponds under study are situated at Bund Road Lahore about 10 km from the University. The sewage supply to the pond is through a 4 inch dia AC pipe making connection from each of the four raising mains of a nearby sewage pump station to deliver the sewage under pressure. The size of each pond 46 m by 18 m at the top with a width of 1.5 m. and size slopes of 1.5 (H) to 1.6 (V). It was envisaged that the sizes so selected would offer pond operation over a wide BOD loading range (50 to 30B lbs/acre/day). The ponds are designed to facilitate series operation, if required, between the paralled units. During the investigation period the facility provided treatment for the population equivalent 750-1000 persons. The facility also included an effluent drain to dispose off the effluent an effluent sum to cater for the flows from all the four ponds and a pump station. A layout of pilot scale stabilization ponds is showing Fig. 1

Costs

Although waste stabilization ponds require more space than most other methods, the construction, operation and maintenance costs are lower and may even the less half. Extensive cost comparison studies were made and are reported in Table 1, which shows calculated values of the ratio of construction cost per several conventional treatment type to the cost of waste stabilization ponds. These ratios do not include land cost, but they clearly indicate the economic advantage which the waste stabilization ponds could offer. Values given in Table 1 suggest that the following land ratios might be involved : Cost data per conventional treatment has been taken from U. S, Dutch and South Africa (1). The data is plotted in Fig. 2 to show how the Capital costs rise steeply for small communities whether in a developing or developed country, the cost of sewage treatment per person increases quite shorply as one deals with populations smaller than 50,000 and ways and means must be found per holding down the costs.

TABLE 1

Ratio of Construction Cost of Conventional Treatment Plants with respect to Cost of Waste Stabilization Ponds of the same Capacity

Design Population	ASP	TFP	PTP	ITP
	WSP	WSP	WSP	WSP
100	3.7	4.5	3.2	4.0
1000	4.1	4.6	3.4	2.8
10000	4.8	4.8	3.5	2.0
100000	5.8	5.0	4.2	1.4

ASP = Activated Sludge Plant
TFP = Trickling Filter Plant
PTP = Primary Treatment Plant
ITP = Imhoff Tank Plant

$$\frac{\text{Land For PTP}}{\text{Land for WSP}} = 0.40 \text{ to } 0.54$$

$$\frac{\text{Land For STP}}{\text{Land For WSP}} = 0.09 \text{ to } 0.52$$

where land is very expensive, these ratios would decrease the construction cost advantage for waste stabilization ponds.

Materials and Methods

Grab samples of the influent and effluents from the ponds were collected regularly twice weekly for laboratory analyses. Samples for bacterial quality were collected in a sterilized 250 ml glass bottles, ample space was left in the bottle to facilitate mixing preparatory to examination.

Laboratory determinations for physical and chemical parameters such as BOD, DO, COD, Suspended Solids, Nitrogen, Phosphorus and other like parameters as well as bacteriological tests were conducted according to procedures described in Standard Methods (2). Identification of algae was made on a binocular compound microscope. Characteristics markings of each species were compared with standard photographs and sketches given in Standard Methods (2) and Fresh Water Biology (3).

Result And Discussion

Investigations on the pilot facility were carried out under different loading rates, ranging from 75 to 300 lbs BOD/acre/day, and at different depths, ranging from 3 to 4 ft. The effect of process configuration was also studied by running the unit in parallel and in series.

A planned composite sampling programme spreaded over many years has indicated that Lahore sewage is moderate in strength in terms of BOD and as an average a figure in the vicinity of 200 mg/1 can safely be quoted with 95% confidence limit as 142-286 mg/1. COD of the influent received at the ponds varied from 700 to 905 mg/1 indicating a poor treatability of the wastes.

During the first phase of investigation the ponds were operated in parallel at different depths and loading rates. Table 2 summarises the overall effluent quality variations in terms of BOD removal and are illustrated in Fig. 3 and 4. It appears that increase in operational depth results in better performance in terms of BOD removal. Increasing depth in fact, increases the detention time in the pond and therefore results in better performance. The data collected did not show any significant changes in performance at various loading rates although it appeared that higher loading rates might tend to improve the efficiency. In fact many other factors may change the pond efficency. For instance the intensity and duration of sunlight available and the operating temperature significantly affect the BOD removals. Similarly variations of the effluent BOD are highly dependent on the variations of the influent BOD, extent of complete mixing and the nature of organisms present in the pond. The data indicated a higher BOD removal efficiency at higher temperature, However, it is difficult to quantify the relation. Temperature changes are generally associated with sunshine hours and intensity of light which affect algal growth. At increased temperature when the microbial activity increases stratification of the ponds tries to retard the process efficiency by inhibiting the pond mixing and preventing the passage of dissolved oxygen into the lower pond levels. Similarly at high temperatures leachates from formentation of settle sludge may cause the deterioration of the effluent quality thus over masking the effect of temperature. Marais (4) has also reported that over the annual cycle of hot and cold weather little variations in the effluent quality were noted from a series of ponds receiving a constant feed of wastewater. From the results it may be concluded that the performance of waste stabilization ponds may change from time to time operating conditions and may show little variations under different operating conditions. It was therefore not unexpected to observe wide variations from day to day in the effluent quality from the stabilization ponds. As experienced, effluent BOD of various ponds operating under

TABLE 2

Comparison of Performance of Various Ponds Operating in Parallel

Pond No.	Period of Study Months	Temp C°	Depth Ft	Loading lbs BOD/A/D	BOD Removal (%) range
i.	Oct. 1983-Mar. 84	5—15	3	75	69.8—82.9
	April-Sept. 1984	16—32	4	75	70.6—84.5
ii.	Oct. 1983-Mar. 84	5—15	3	150	67.0—82.0
	April-Sept. 1984	16—32	4	150	72.7—82.5
iii.	Oct. 1983-Mar. 84	5—15	3	250	63.5—70.5
	April-Sept. 1984	16—32	4	250	69.5—83.5
iv.	Oct. 1983-Mar. 84	5—15	3	200	69.8—80.0
	April-Sept. 1984	16—32	4	200	78.0—84.4

different loading conditions ranged from 32-85 mg/l with an average BOD removal range as 69.5 to 86.7%

Removal of Nutrients By Waste Stabilization Pond

Samples	Nitrogen mg/l	Phosphorus mg/l	Potassium mg/l	Calcium	Iron mg/l
Influent	19.4—20.0	2.0—3.7	1.0—2.4	16.4—29.6	2.0—4.9
Pond 1	8.3—10.2	1.2—1.7	0.3—1.9	9.2—20.2	0.7—2.8
Pond 2	8.7—10.0	1.3—1.6	0.7—1.4	9.7—19.2	0.4—1.7
Pond 3	8.5— 9.8	1.3—1.7	0.9—1.5	6.6—17.0	0.9—2.9
Pond 4	8.0— 9.3	1.3—1.7	0.6—1.6	7.0—16.4	0.6—2.7

Investigations were also made to see the nutrients removal efficiencies of the ponds. The object was to make sure that the treated effluent which will be discharged into the receiving river will not create problem like that of eutrophication, because the fertilization of natural waters may result in the production of excessive growth of algae and higher plants, these crops may cause serious deterioration of water quality. Removal of nitrogen and phosphorus and other nutrients during the investigation period is shown in Table 3. Nitrogen in wastewater is almost entirely

in the form of ammonia and organic nitrogen compounds. Reduction of nitrogen took place in all the ponds. On an average a reduction of 50 to 60% was achieved in each pond. Although exact mechanism is unknown, it is thought that the organic portion of total nitrogen was reduced by bacterial action whereas ammonia nitrogen nitrogen was chiefly reduced by algae. The average utilization of phosphorus varied from 30 to 67% for each pond, which clearly shows the utilization of phosphorous by algae for their cell syntheses. Since unfiltered samples were analysed for nitrogen and phosphorous, it can be safely gathered that sedimentation was also one of the main reasons for such reduction. Significant removal for Iron, Calcium and Potassium was also achieved.

TABLE 4

Reduction in Various Parameters by Waste Stabilization Ponds Operating in Parallel

Parameter	Influent	Pond I	Pond II	Pond III	Pond IV
Name	mg/l	mg/l	mg/l	mg/l	mg/l
PH (Average of 48 determinations)	7.2—7.4	8.4—9.0	8.3—9.1	8.4—9.1	8.4—9.0
Total alkalinity av. of 48 det).	364	306	325	316	306
Settleable Solids (av. of 48 det).	2.0	0 3	0.3	0.2	0.5
Suspended Solids av. of 48 det.)	258	346	372	358	362

Changes occuring in LCH. total alkalinity, settleable solids and suspended solids are shown in Table 4. In waste stabilization ponds pH is controlled through the carbonate buffering system. The equilibrium of this system is affected by algal photosynthesis. In photosynthetic metabolism by algae, CO_2 is removed from the dissolved phase. This tends to decrease or increase the pH and decrease bicarbonate alkalinity. The decrease alkalinity associated with photosynthesis will simultaneously reduce the carbonate hardness present in the waste. Because of the close relationship between pH and photosynthesis activity considerable diurnal fluctuation in pH and alkalinity is observed. It was very surprising to note that no reduction has been achieved in the SS contents of waste stabilization ponds. Instead of reduction

an increase the SS contents has taken place. This is due to the fact that most of the SS in the ponds are in the form of algae cells. As the influent containing SS enters the ponds, due to the presence of nutrients algae cells begin to grow and as they are mostly in suspended form, the SS contents of the pond increases. Hence in waste stabilization ponds the pond efficiencies are always shown in terms of BOD reductions and not in SS reduction.

TABLE 5

Bacterial Reduction in Waste Stabilizing Ponds Operating in Parallel at various Loading and Depth

Pond No.	Temp. °C	Depth Ft	Loadings lbs BOD/ acre/day	Coliforms Removal Range—%	E. Coli Removal Range—%
1	5—17	3	75	90.5—99.0	96.2—99.8
	18—30	4	75	90.2—99.6	98.7—99.9
2	5—17	3	150	88.6—92.0	90.4—95.7
	18—30	4	150	97.5—99.2	98.8—98.2
3	5—17	3	250	93.0—98.3	95.0—98.6
	18—30	4	250	96.5—99.3	98.4—98.9
4	5—17	3	200	94.0 - 97.7	96.8—97.7
	18—30	4	200	96.0—99 0	97.4—99.8

Table 5 shows bacterial reductions achieved in various ponds at given depth and loading operation at 4 ft depth resulted in better removal efficiencies. This might be due to longer detention time Gloyna (5) has suggested pond operation in series to obtain higher bacterial reductions. The use of maturation pond may also adequately serve the same purpose. Owning to the needs of maintaining river water quality in most of the tropical countries. It might be more important to destroy faecal pathogens in sewage treatment. The result of the present investigation suggest that single facultative pond system may therefore not result in satisfactory coliform removals. Reduction in Coliform bacteria in any pond system has been reported to follow first order kinetics. The analysis of the performance data, however, did not show any satisfactory fit to the expression.

After operating all the four ponds in parallel, the mode of operation was changed to series system. Only the pond could be operated in series as the other two ponds had developed certain structural defect. Pond No. 4 was assumed as Pond 1 and Pond 3 as Pond 2 owning to certain defects in maintaining a depth of 4 ft. Pond No. 1 was operated at a depth of 3.75 ft whereas Pond 2 which received effluent from Pond 1 a depth of 3.5 ft was maintained. The waste lewater flow to Pond 1 was regulated so as to produce a loading rate of 300 lbs BOD/acre/day. The study was made for six months and the results obtained are shown in Table 6. During this study it was specially noted that the Coliform count of the influent was very high and ranged from 1.2×10^8 to 42×10^8/100 ml as compared to previous investigation. Mean experimental results of the series performances of the ponds have been produced in Table 6. Table 7 shows the average removal efficiencies in terms of BOD, COD SS and Coliforms.

TABLE 6

Mean Experimental Results for Interseries System Loading of Pond 1,300 lbs BOD/Acre/Day

Sample	BOD	COD	SS	pH	Ammonia-N	Coliforms
	mg/l	mg/l	mg/l	range	mg/l	Per 100 ml
Influent	189	446	361	5.9–7.6	25.2	20.8×10^8
Pond 1	49	170	436	6.2–8.6	2.8	12.0×10^3
Pond 2	38	141	390	6.5–8.5	1.9	1.98×10^3

BOD = Biochemical Oxygen Demand
COD = Chemical Oxygen Demand
SS = Suspended Solids

TABLE 7

Average Removal Efficiencies in Interseries System

Parameter	Pond 1	Pond 2	Overall
–	%	%	%
BOD	74.0	22.4	79.9
COD	61.9	17.0	69.4
SS	Nil	Nil	Nil
COLIFORMS	99.9	83.5	99.9

It was concluded that the system could produce on average an overall BOD removal of 79.9% whereas Coliform removal efficiencies in Pond 1 and in overall system were of the order of 99.99% These results clearly indicate that the Coliform removal in facultative ponds does not take place according to some specific relationship and hence it would be over simplified to estimate coliform removal on first order kinetic basis. The overall results however advocate for the adoption of a serice system for higher coliform removals. Biological studies were also carried out on ponds operating both in parallel and in series. Table 6 shows an increase in the 55 content of the pond, this is due to the algae which flourishes in the pond effluents and add to the Ss content of the ponds, hence percentage removal of SS is considered nil (Table 7). The most common algal species identified from ponds operating in series and parallel are shown in Table 8.

TABLE 8

Most Common Phytoplanktons Observed in Waste Stabilization Ponds Operating in Series & Parallel

Period	Temperature	Algae	Microscopic Animals
Season	C°	Species	Species
Summer	20 – 31	Oscillatoria	Paramecium
(May to mid July)		Spirulina	Vorticella
		Euglena	Daphnia
		Phacus	Rotoria
Monsoon	18 – 26	Oscillatoria	Paramecium
(Mid July-mid		Euglena	Vorticella
September)		Chlorella	Brachionus
		Lepocinclis	
Winter	5 – 17	Chlamydomonas	Paramecium
(Mid Sept-		Chlorococcum	Vorticella
January)		Euglena	Euplotes
Spring	15 – 22	Chlorella	Paramecium
(Feb-April)		Euglena	Vorticella
		Chlamydomonus	Euplotes
		Phacus	

It is not intended as a complete list but rather represents large growths as observed in ponds. Examination of these organisms indicate that these algae

belong to three general groups, the motile algae, the non-motile small algae and the filamentous algae. The motile algae have the ability to move and compensate for varying light conditions. *Euglena gracilis* were the most frequent algae. It was present throughout the investigation period. *Chlorella Vulgaris* was the non-motile algae that present a large surface area to mass ratio so that they remain suspended with very slight fluid motion. The prmary filamentous algae were the blue-green *Oscillatorianlauterbornii* these algae tend to form floating mates that are undesirable in ponds as they block light transfer mixing and surface reaeration.

The predomination of various algal species was dependent upon the loading factors at a loading of 75 lbs BOD/A/D a different microbial population was observed as compared to other loadings. Also with increase in depth, there was an increase in the total algal cells. The results are shown in Table 9. According to Khurshid and Tariq (6) a slight increase in the number of algal species is observed as the depth of the ponds are increased from 3 to 4 ft.

It was also observed that as the pond temperature approached 50°C green algae were replaced by blue-green algae *Oscillatoria lauterbornii*) these filamentous algae usually forms algal mats at the pond surface with the result light could not penetrate at the lower depth of the pond, resulting in decrease photosynthetic activity and hence affecting overall pond efficiency. Results of study are illustrated in Fig. 5. During periods of bloom ponds also emitted a characteristic odour that was frequently detectable from a distance of about 15 m. The mats were usually wind driven, they moved from shore to shore by changes in wind direction. The mats were broken up with heavy rain reforming within a few days in hot weather. In other instances, particularly during periods of high water temperatures, sludge mats rise from the bottom. These masses of organic debris usually accumulate in corners, and if it is not disturbed the entire mass may become covered with blue-green algae. Usually the bacterial activity is intense and the odours are overpowering. The best way to keep the ponds clear of algal mates and organic debris is to remove them manually from time to time.

In all probability, an odour or a charge in colour is a warning of a major change in the performance of a pond system, and the operator should be alert to recognize such signs. Occasionally points during winter developed pink colour. This was due to the development of a coloured algal species chromatium and thiospirium. These species usually occurred when the sulphate contents of the pond increased beyond 38 mg/1. Alongwith these species various other species of small rod-shaped and spiral firms were detected which could not be identified.

Waste stabilization ponds have been reported to be a significant factor for serious consideration in promoting the use of stabilization ponds as a low cost wastewater treatment method, especially in malaria infected areas where ponds often represent an attractive alternatives for wastewater disposal. Observation spreaded over several months of operation demonstrated that no mosquito problem arose when the ponds were being operated at higher loading rates. It is recommended that the operation of facultative stabilization pond can be trouble free provided scumming of floating material and removal of vegetation from the banks is practised on regular basis. The ponds situated in semi-arid regions mosquito breeding will definitely occur in ponds having unlined dikes for such ponds larvicidal measures should be undertaken. According to Khurshid (7) (8) the following larvicides will prove useful ; a thin layer of kerosene or dissel oil, 2% DDT and oil, bundane dust (3% gamma isomer), and 2% malathion. Caution should be exercised when using these substances, for excessive use may produce harmful effects on receiving water courses.

Sludge deposition in the ponds was quite slow a point which goes in the favour for waste stabilization ponds. After parallel operation pond No. 3 and 4 were connected for series operation and Pond 1 and 2 were dried up for measurement of accumulated sludge. During three years of operation a sludge layer of five inches had accumulated as the pond bottom. The influence of this sludge layer on the pond can be described as follows. During the early life of pond receiving settleable solids, a portion of the observed roduction of BOD in the pond is due to the settlement of organic material as sludge. Anaerobic fermentation develops in the sludge reducing its organic load but releasing fermentation products to the pond liquid. Under uniform conditions of deposition and temperature the volume of sludge will increase, releasing correspondingly greater quantities of fermentation products, until a state of equilibrium is reached in which the BOD added to the sludge by new deposits is equal to the BOD released as fermentation products. During the cold season, little breakdown taken place in the sludge and the pond bottom becomes primarily a sludge storage area. During hot season, the fermentation products from the sludge and to the BOD in the pond liquid. Eventually a condition is attained where there is an annual cyclic variation in sludge volume, high in the winter and low in the summer. During the summer the increased feed back of fermentation products from the sludge to the pond and turn it anaerobic. This is particularly serious if the warmer temperatures coincide with cloud cover that reduces solar radiation.

From public health view point, stabilization ponds may creat certain dangers. In limestone areas possibility of seepage into aquifers should be guarded against.

Anaerobic ponds, in addition to occasional odour problems, may give rise to fly breading, if a dry scums forms which is not promptly broken up. Facultative and aerobic ponds may occasionally support mosquito breading. Smails capable of transmitting bil harziases have been received from an aerobic pond in Uganda. All these vectors represent potentially dangerous situations in countries where the diseases they transmit are prevalent, and point to the need for reliable operation and health department surveillance.

Conclusion

The following conclusions were drawn by operating waste stabilization ponds situated in Lahore in parallel and in series at loadings varying from 75 to 300 lbs of BOD/acre/day and at depth from 3 to 4 ft.

The operation of the pilot scale facility has shown that facultative ponds are one of the successful treatment alternatives under semi-arid conditions. Satisfactory performance of the facultative stabilization ponds can be expected in terms of BOD removal at a loading rate of 200 lbs of BOD/acre/day and at operational depth of 4 ft. However to arrive at more economical criterion for design, studies should be conducted at 5 ft operational depth.

Ponds were equally capable in removing nutrients, 50 to 60% of nitrogen and 30 to 67% of phosphorous was removed by the ponds. Significant reduction in suspended solids, settleable solids increase in pH and fluctuations in total alkalinity was also observed. Bacterial removal efficiency was not satisfactory at some of the loadings studied in parallel operated ponds. Satisfactory bacterial removal efficiency of 99.99% was achieved in ponds operated in series and at loading rate of 300 lbs of BOD/acre/day. Phytoplankton observed belong to three general classes, motile, non-motile and filamantous, their occurrence in the ponds were affected by various loading rates, and depths. High temperature favoured the formation of undesirable blue-green algal mats which also emitted odour. At this temperature sludge mats also rise from bottom and adds to the odour of the ponds. Ponds during the investigation period was free from mosquito breeding. During three years of pond operation only five inches of sludge layer were accomulated in the ponds bottom.

Recommendations

Since the facility did not allow to carry investigations at 5 ft depth, there is a need to rebuild the facility to check the performance at 5 ft depth. The need is strengthened by the fact that depths of facultative ponds are now widely standardized by 1.5 m. At such depth solar radiations penetrate through much of the

depth and there is no danger of rooted plants or attached algae in the bottom. It is felt that the inclusion of an anaerobic pond in the system might result in a more economical process for the treatment of Lahore sewage. The performance of the ponds in terms of bacterial removal also suggest for the inclusion of maturation pond in the system.

Acknowledgement

The author wishes to thank Prof. Dr. M. I. D. Chughtai former Dean of Science and Engineering Punjab University Lahore for his guidance during the investigation period. Thanks are also due to Jawed Sarwar and Saeed Mirza Laboratory Technicians for their help in laboratory analysis of the samples and all the laboratory staff for their cooperation.

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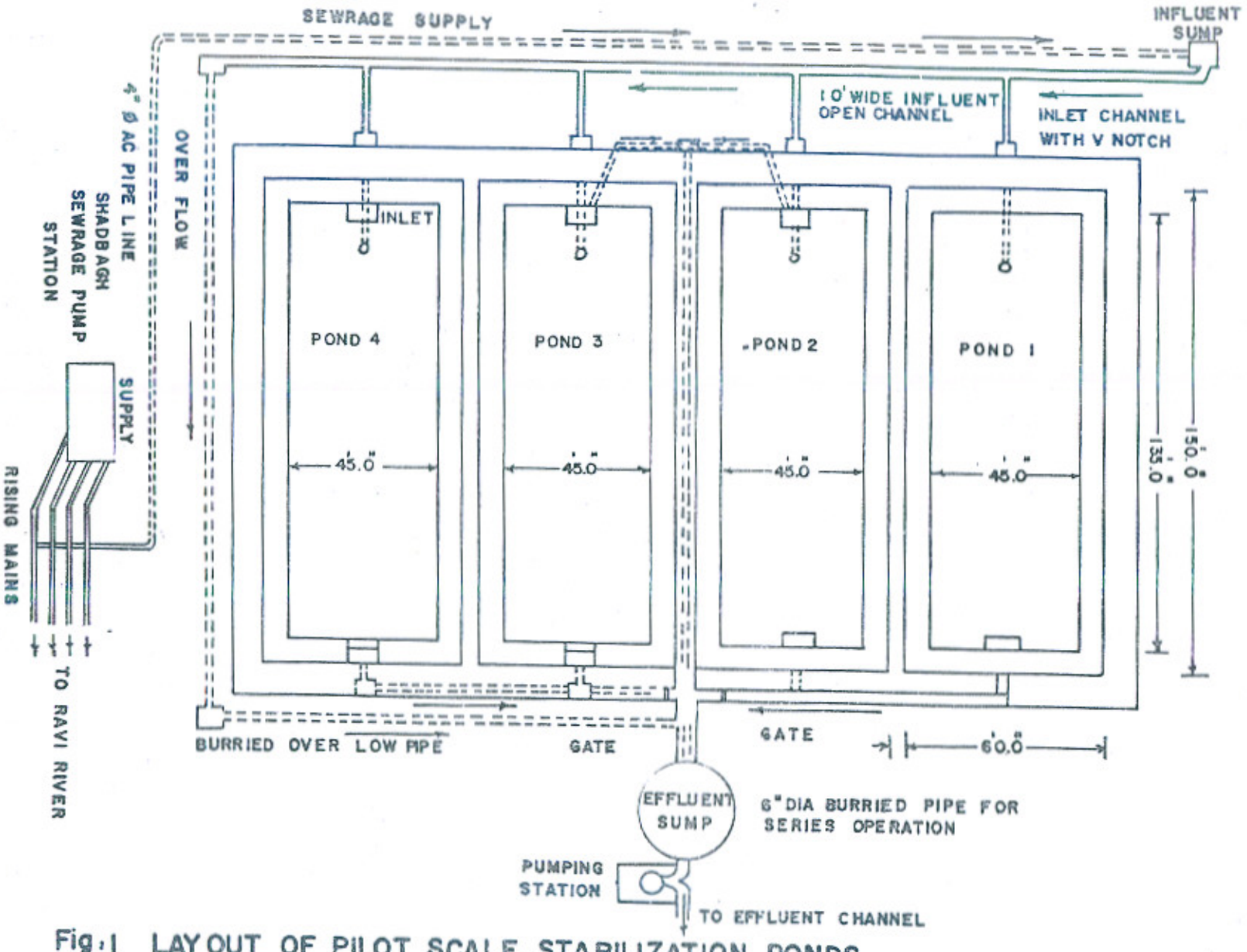


Fig.1 LAY OUT OF PILOT SCALE STABILIZATION PONDS

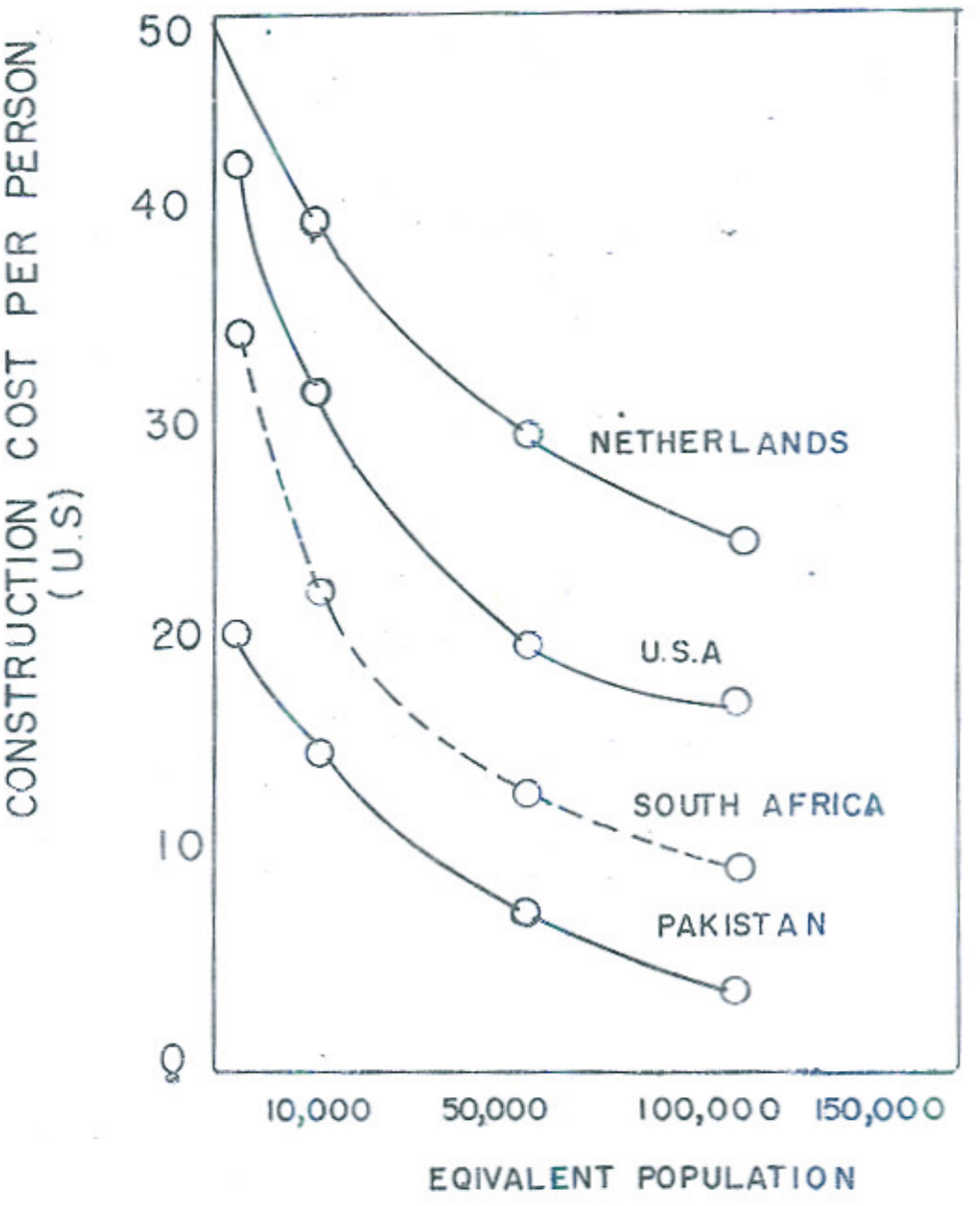


Fig: 2 CONSTRUCTION COST OF SEWAGE TREATMENT PLANTS WITH SECONDRY TREATMENT.

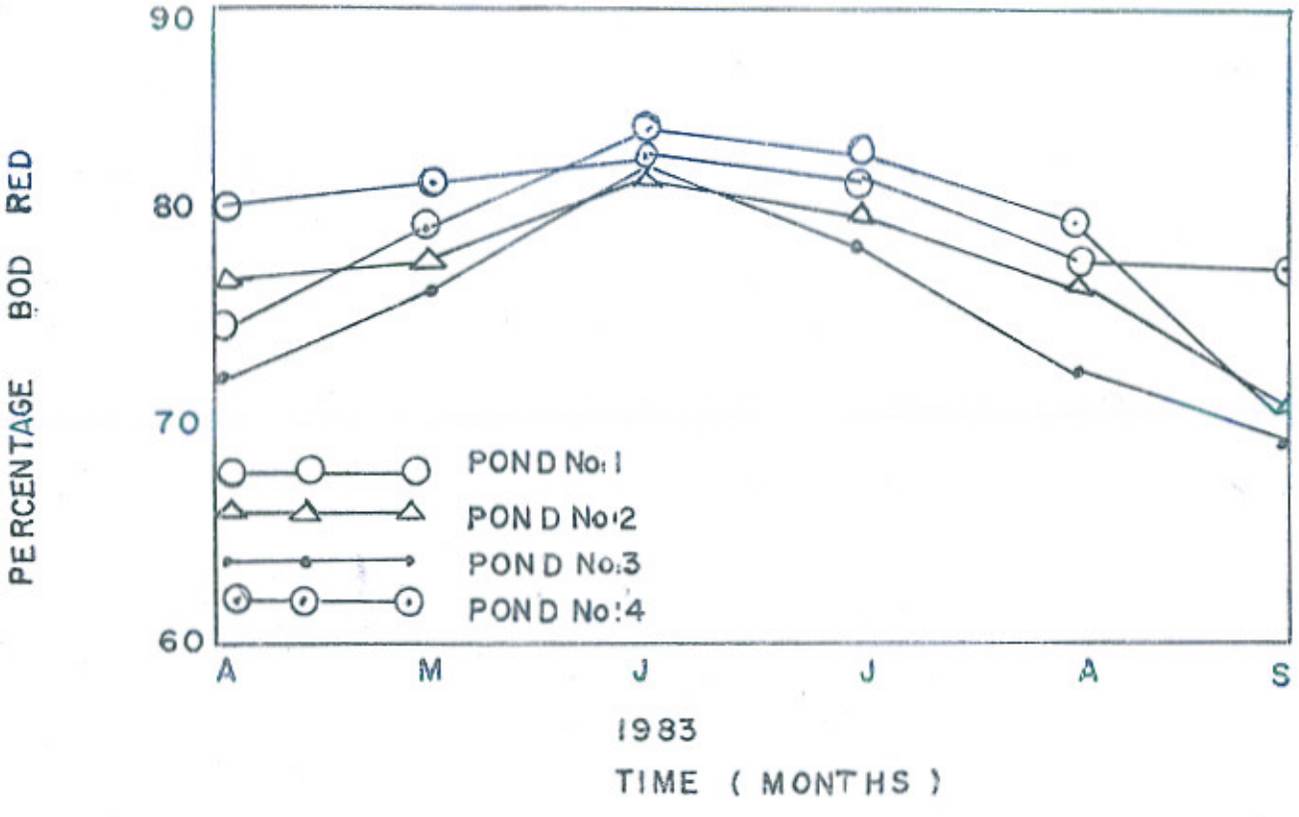


Fig.3 PERCENTAGE BOD REDUCTION IN POND No:1,2,3 AND 4 AT A DEPTH OF 4FT AND SURFACE LOADINGS VARYING FROM 75' TO 250' LbsBOD/A/D

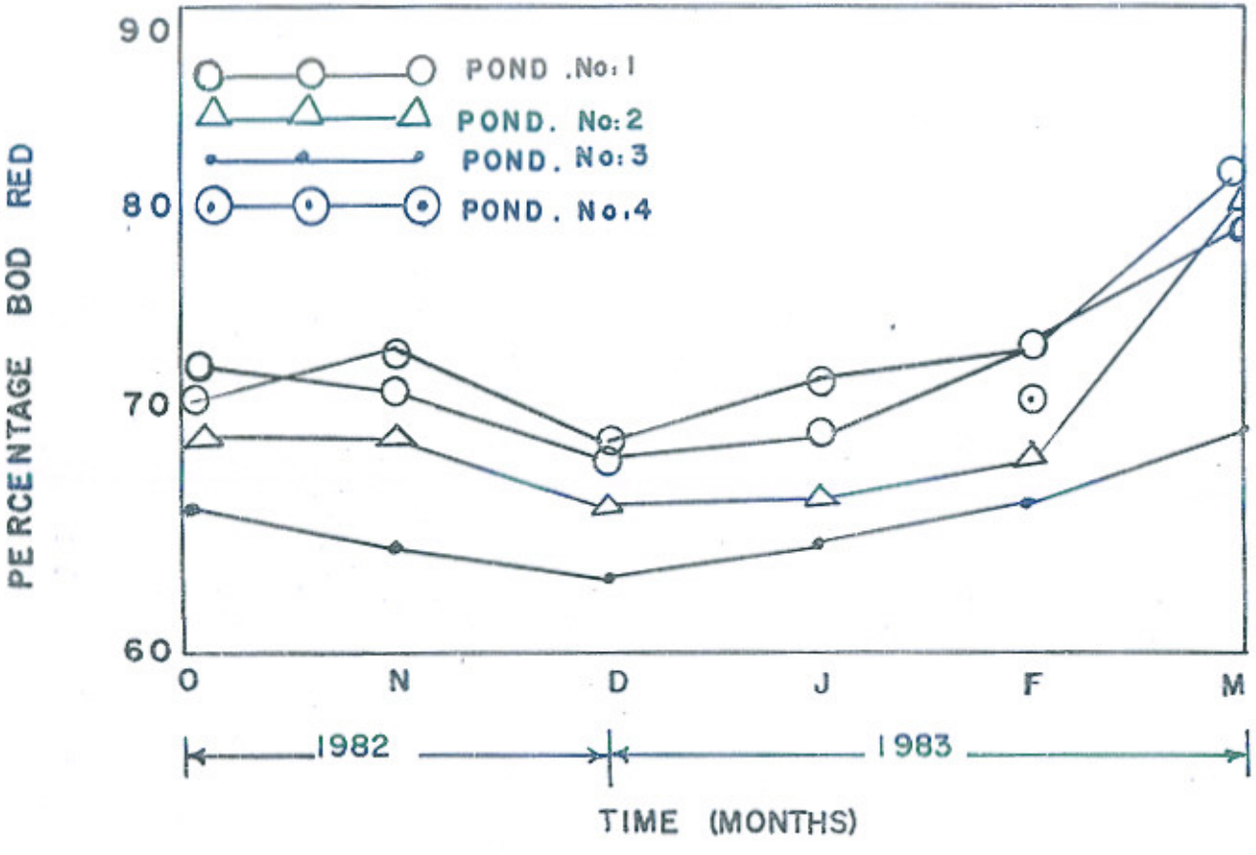


Fig:4 PERCENTAGE BOD REMOVAL IN POND No: 1, 2, 3, AND 4 AT A DEPTH OF 3FT AND SURFACE LOUDINGS VARYING FROM 75' TO 250' LBS BOD / ACRE / DAY

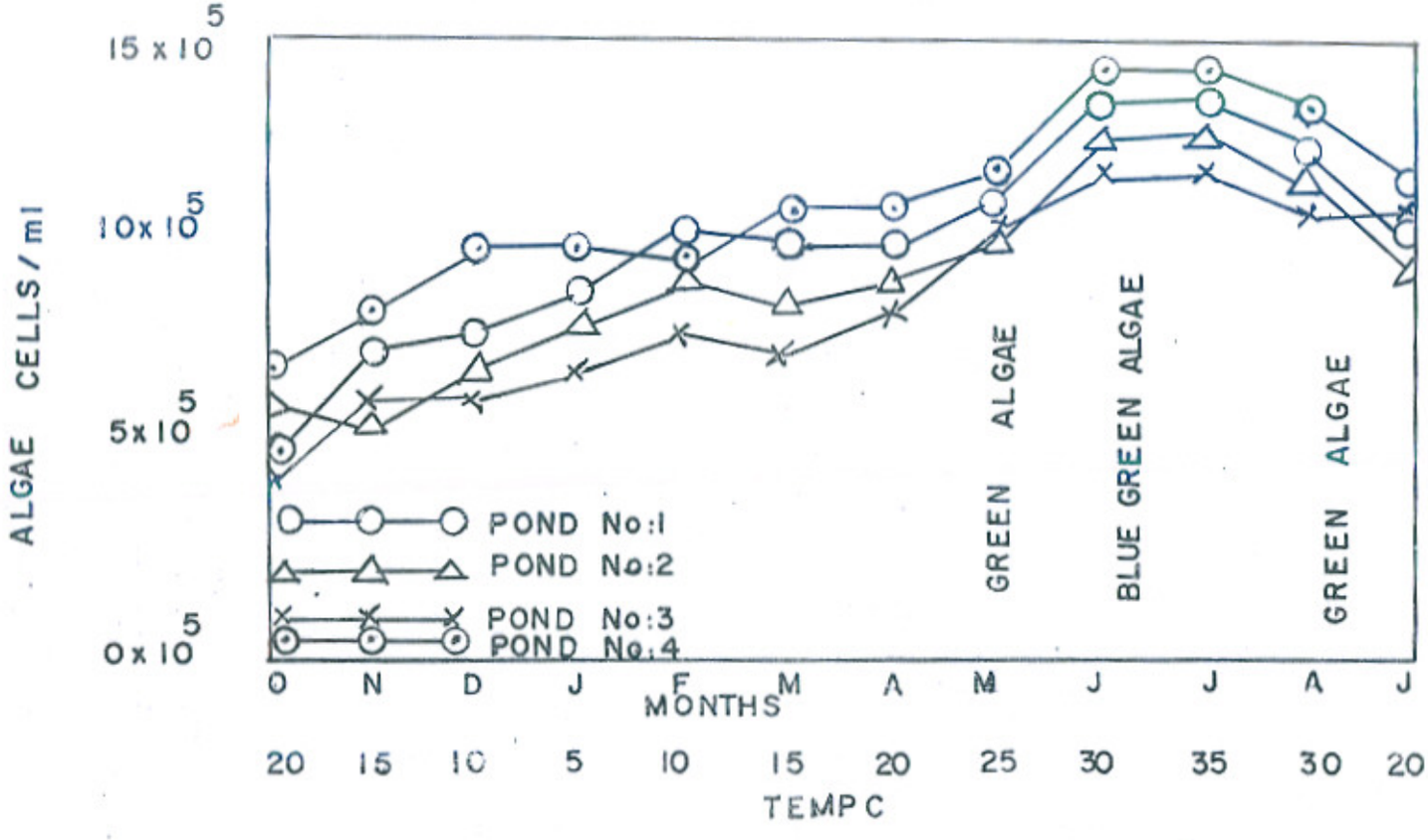


Fig: 5. GROWTH PATTERNS OF ALGAL SPECIES IN POND 1, 2, 3 AND 4, OPERATING IN PARALLEL LOADINGS VARYING FROM 75° TO 250 Lbs BOD/A/D

The Analysis and Design of Single Layer Spherical Skeletal Braced Domes

by

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1. Abstract

This paper demonstrates the procedure for the analysis and design of single layer skeletal braced domes. It also introduces the reader with various problems which are normally encountered during the analysis and design of a structure having double curvature. A design example, supported by structural drawings, of a spherical skeletal dome of span 90 meters curtailed to a square cross-section of 70×70 meters in plan with a rise of 12.5 meters at the centre, is also presented. This dome has been analysed for different load and boundary conditions by using finite element method on a PRIME 750 on line computer network. Linear elastic analysis and stability analysis have been performed by using half of the structure and full structure separately. All aspects involved in the design have been discussed.

2. Introduction

The domes provide an easy and economical method of roofing large areas without having internal supports and are used very frequently by those designers who realize the advantages and impressive beauty of this form of construction. These are of special interest to structural engineers and architects as they enclose maximum space with a minimum plan area.

Domes are exceptionally suitable for covering sports stadia, swimming pools and exhibition centres where large unobstructed areas are essential. The correct

estimation of live loads and especially of wind load on a spherical structure is a very difficult problem for the concerned structural engineer.

3. Estimation of wind Loads

Wind loading hand books give reasonably good pressure co-efficients on flat surfaces but their use for structures having double curvature gives very erroneous and misleading results. The presure co-efficients are usually obtained from wind tunnel tests.

Surface pressures are believed to depend on Reynold's Number, turbulance intensity, length scale, boundary layer immersion and surface roughness. For a full size dome the inspection of Reynold's Number reveals that dome is usually in a super critical range. Therefore, it is recommended that the tests on domes should be carried out in this range. In fact the problems of getting reliable data on any dome are so great that the experts often advise to overdesign on the basis of best available information.

The mounting of domes on a raised cylindrical base, as is the case in the design example, results in a greater range of pressure co-efficients than for domes resting directly on ground. Internal pressures should always be considered while arriving at the correct estimate of wind loads. Therefore, it is recommended to seek an expert advice for calculating wind loads on spherical domes.

4. Assumption made in load Calculations

The following assumptions are usually made and these give reasonably good estimates of loads which are usually on the safer side :

- Distributed loads are replaced by their equivalent static nodal loads to facilitate the data preparation for computer input.
- Dead load is proportional to area in plan
- An empirical formula suggested by an authority on the topic states that

$$\text{Dead load } (KN/m^2) = (0.3 + \frac{\text{span of dome in meters})}{100}$$

- Live load is increased by 60% to cater for wind load etc.

These assumptions were actually verified later on in the design example.

5. Unsymmerical snow Loading

If the wind and snow act simultaneously on a shallow dome, there is a tendency of snow to accumulated in a localized area on the leeward side. This

unsymmetrical snow loading on shallow domes is responsible for the phenomena which is known as 'snap-through buckling'. Alinear analysis of a shallow elastic structure with non-linear unstiffenlng characteristics will normally underestimate the displacements. Therefore, for these structures, a non-linear analysis is recommended.

Under the action of unsymmetrical loading the unstiffening associated with small deformations may by gradual reduction reach a stage where stiffness of structure is lost completely. It can be said that the load-deflection equilibrium path of the structure has reached a 'limit-point' and a dynamic jump to a highly deformed configuration would occur, This type of instability is called snap through buckling and should always be checked in case of shollow arches and domes.

According to Reissner's shallow criterion[7], a dome would be shallow if

$$\frac{H}{D} \leqslant \frac{1}{12}$$

where H is the height of dome, and

D is the span.

By applying this criterion, the dome in design example is a shallow one.

The unsymmetrical snow loading on the structure can be simulated as a structure loaded with dead load on whole of structure while having live load on half of it. As this loading gives some idea about the stability of structure it is necessary to neglect the advantage due to symmetry of structure and whole of the structure has to be analyzed.

6. Joint System of the Dome

Because at some of the joints various circular hollow tubular members having different sizes meet together, the ROBAK joint system whose details have been shown in Fig. 2 has been selected in the design example as it overcomes the above mentioned problem.

ROBAK joint consists of two hemispheres which would be butt welded together after all the members meeting at that joint have been butt welded to these two hemispheres. Therefore, this joint is very suitable for any curvature of the dome. Welding in this joint is always carried out at site.

7. Dome Cladding

Steel sheets are used extensively for cladding modern buildings like domes etc. The lengths of steel sheets between different great circles is usually calculated by using empirical relationships. The cost of cladding has a great significance and

influences the total cost of structure. Therefore the type of cladding material and cladding scheme should be selected very carefully. In the design example, steel cladding has been used.

8. Thermal Insulation of Dome

Thermal insulation is provided to reduce the effect of wide variation in external temperature on the internal temperature. Usually thermal insulation is provided immediately under the roof covering of the dome and is carried out by the cladding contractor. Therefore, no separate scaffolding is required for providing thermal insulation. A controlled temperature range can be maintained within the dome throughout the year.

9. Drainage

The details of water drainage over the spherical dome clad with steel sheets have been shown in Fig. 3 and 4. The surface has been assumed impervious and the system has been designed for a rainfall of intensity 75mm/hr. The water would be collected in the channels placed along the four sides of the dome. It would be connected with the ground water disposal system by means of four cast iron pipes one at each corner of the dome.

10. Method of Erection

The skeletal dome is assembled at ground level by using simple scaffolding and it would be lifted to its final position. There can be two possible erection methods :

- When perimeter consists of a series of peripherial columns of different heights.
- When perimeter consists of peripherlal colums of equal heights with a spherical skeletal 'facia girder' of 12.5 meter height at the centre on top of columns.

A thorough study would reveal that in second case, a peripherial 'facia girder' consisting of trusses with spherical upper chord is required. Therefore, it is recommended for the dome in the design example that colums of different heights would result in an economical erection method. First of all the perimeter columns are erected to the required heights and would be properly braced. Then skeletal dome is assembled within the perimeter with a minimum clearance of 50 mm between the dome edges and the inner surface of the perimeter columns.

As the dome would tend to flatten out and show deflections when it is lifted,

it is desirable to tie the dome diagonally so that deformations during lifting procedure could be restricted. The dome is then lifted upto its final position by using hydraulic jacks placed at appropriate positions. It is imperative that jacking operation is done with extreme care so as to avoid differential jacking. It is possible only when all the jacks are controlled by a central monitoring system. After complete lift the diagonal ties are released so that the dome would flatten out and rest exactly on the centre of the columns. A computer analysis was perfomed which verified that erection stresses would be within permissible limit and that the do me would eactly rest on centre of peripherial columns. Fig. 5 shows the structural detailing at the supports. The details of linear elastic analysis and that of stability analysis are being presented in Tabel-1.

11. The Analysis

The design of single layer skeletal domes having double curvature has become possible with the increased knowledge of the behaviour of space frames which has come about because of the use of great analytical capacity of the modern computers. The most general method is to use the standard three dimensional computer analysis. The method gives satisfactory results if the structure is basically stable and is without any inherent instability. Shallow domes exert a tremendous horizontal thrust at the springings. Therefore, single layer skeletal tubular braced domes can have a maximum span of 100 meters beyond this double layer skeletal braced domes can be provided. Single layer shallow domes having a long span need to be analysed for any possible instability that may occur.

For the analysis of the dome presented in design example, finite element method has been used with six degrees of freedom per node. Programmes were written in FORTRAN 77 to generate the dome co-ordinates in double precision, to generate various load cases and to compute the total weight of the dome etc. The structure data file is completed first and the structure is viewed on a graphics terminal. Fig. 1 is actually a reprint of computer output of structure data file and shows the numbering scheme and the final section of the members.

12. Design Example

It is required to design a spherical single layer skeletal dome curtailed to a square cross-section in plan for a proposed olympic swimming pool. The dome is supported by peripherial walls 10 meters high.

Data :

Span	=	99 meters
Rise	=	12.5 meters

Boundary condition	Load case	SIZE OF THE Internal members	Bracing members	Edge members	Weight of Dome (tons)	Maximum Deflection (mm)	Maximum allowable Deflection (mm)
a	one	193.7x5.4CHS Grade 55	273x10CHS Grade 50	193.7x5.4CHS Grade 55	113	112.7	275
	two	—do—	—do—	—do—		185.1	
b	one	193.7x5.4CHS Grade 43	273x10CHS Grade 50	193.7x5.4CHS Grade 43	113	70.0	275
	two	—do—	—do—	—do—		124.0	
c	one	323.9x10CHS Grade 60	457x16CHS Grade 55	457x16CHS Grade 60	387	185.0	275
	two	—do—	—do—	—do—		221.0	

TABLE — 1 : Comparison of Section sizes and vertical deflection for various boundary and load conditions.

Imposed load = 75 Kg/m²
Wind speed at 10 meters above
ground level = 35 m/sec (3 sec gust)

Solution :

The layout including general arrangement of structure, node number scheme and final section sizes is shown in Fig. 1, which is a reprint of computer output of the structure. This dome has been analysed by the finite element method on a PRIME 750 on line computer network for three different boundary conditions and two load cases. Load case one is the linear elastic analysis of the dome while load case two is the stability analysis of the structure.

12.1 **Load Cases**

Load case one — whole of the dome loaded with dead load and superimposed load.

Load case two — whole of the dome loaded with dead load and superimposed load over half of the dome to simulate unsymmetrical dome loading.

12.2 **Boundary Conditions**

a—Simply supported along four sides @ 11.66 meter interval (Fig. one)

b—Simply supported all along four sides @ 2.9 meters interval.

c—Simply supported at four extreme corners only.

For linear elastic analysis (load case one) the advantage due to symmetry has been taken and half of the dome having 625 nodes has been analysed while for stability analysis (load case two) whole of the dome has been analysed and advantage of symmetry of structure has not been taken.

12.3 **Calculation of Loads**

The loads calculated below were converted into statically equivalent applied nodal loads.

According to formula, the dead load of skeletal members is

$$\text{D. L. (KN/m}^2\text{)} = (0.2 + \frac{\text{span in meters}}{100})$$

$$= 1.19 \text{ KN/m}^2$$

$$\text{L. L.} = 0.75 \text{ KN/m}^2$$

Increase live loads by 60% to cater for unsymmetrical live loads and increase dead load by 100% to take care of metalic cladding, insulation and services.

L. L.	=	$1.6 \times 0.75 = 1.2$ KN/m²
D. L.	=	2.38 KN/m²
Design load	=	3.58 KN/m²
	=	$3.58 \times 70^2 = 17542$ KN
Quarter nodes	=	4
Half nodes	=	92
Full nodes	=	529
Load per full node	=	30.454 KN
Load per half node	=	15.225 KN
Load per quarter nodes	=	7.6125 KN

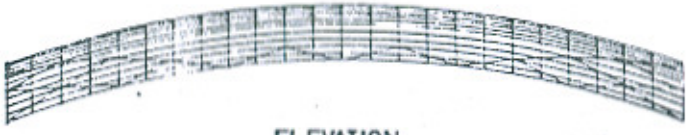
After calculating the nodal loads and viewing structure on the graphics terminal, load data file and structure data file are combined. The computer output contains nodel axial forces, moments and torsional moments etc. Checks for permissible stresses are now applied and member sections can be revised if found overstressed in the next computer run. Deflections are also checked to see that there are within permissible limits.

13. Discussion

The design of skeletal domes remains a very difficult task for the structural engineers. Maximum difficulty is encountered while calculating the exact magnitude of the live loads and specially the wind load. Wind loading handbooks and other design guides are either not in agreement for structure with double curvature or give very misleading results. For example the pressure co-officients taken from the Indian Code indicate a positive pressure of + 1.0 at windward base of the dome, zero at the top and −1.0 at leeward base. This is clearly incorrect because it has been established from the actual measurements that there is always a considerable suction at the top of the dome. Therefore, in the design exam le, live load taken is based upon an expert's advice. It has been found from computer output that Fig. 1 represents the most economical arrangement where the exterior columns are at 11.66 meter interval. It has been further noted that in case of elastic analysis, maximum vertical displacement occurs at the corresponding nodes near the centre. Maximum deflections occur obviously in load case too where we have upward as well as downward deflection of the adjacent nodes in the same quarter. Therefore it is advisable to check the displacements in load case too thoroughly as it gives some idea about the stability of structure under unsymmetrical loading.

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BRACING MEMBERS 273X10 CHS

EDGE MEMBERS 193.7 X 5.4 CHS

INTERNAL MEMBERS 193.7 X 5.4 CHS

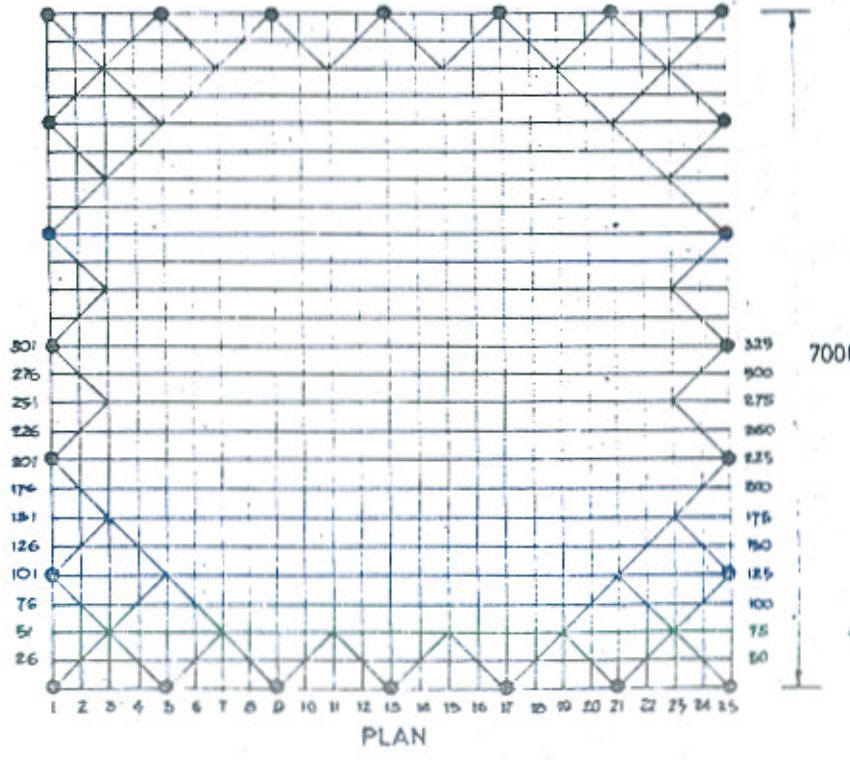


FIG 1 GENERAL ARRANGEMENT OF STRUCTURE

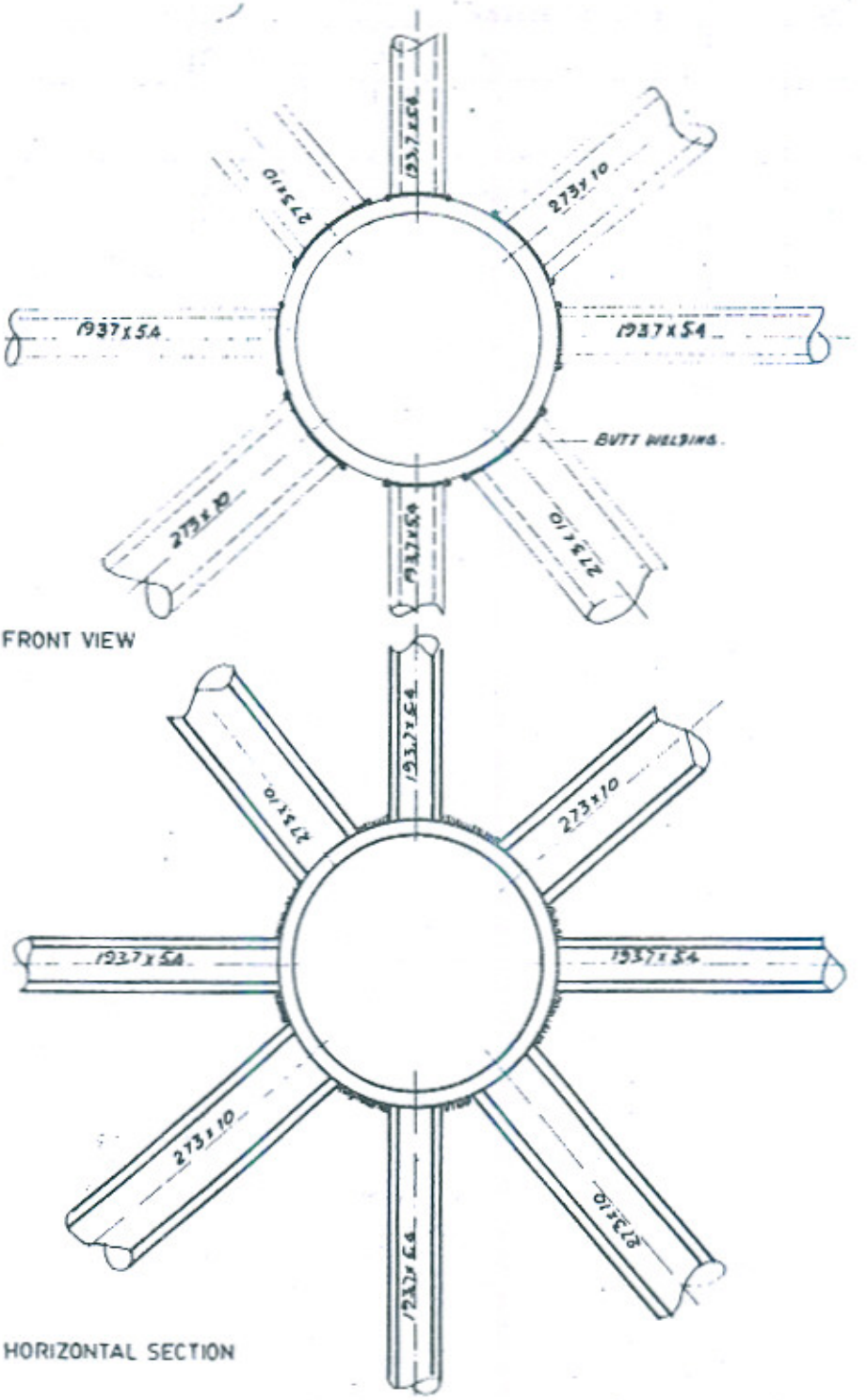
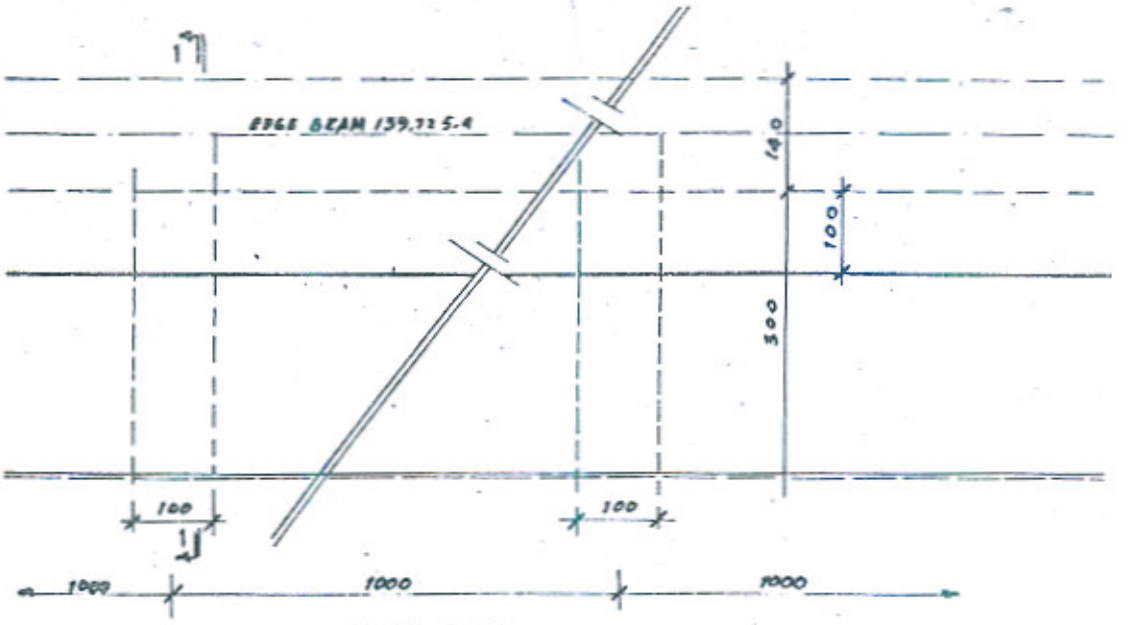
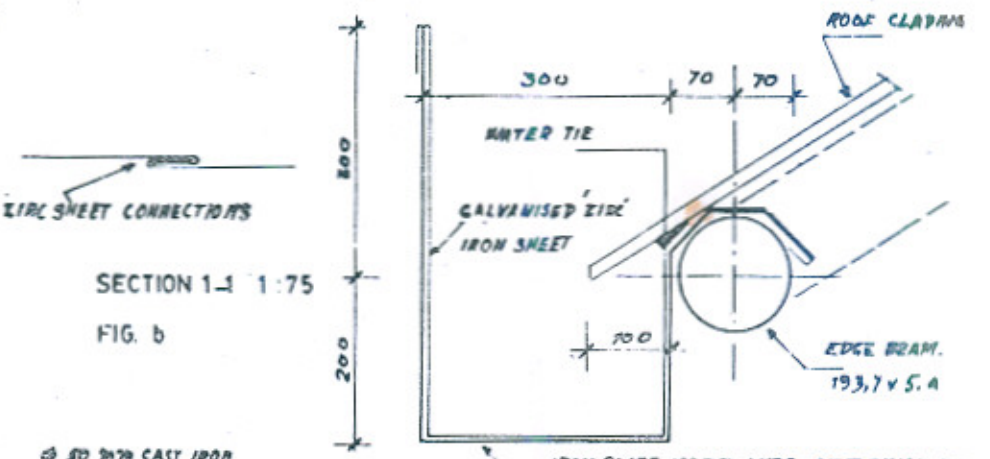


FIG 2. DETAILS OF ROBAK- JOINT SYSTEM



PLAN 1:75



SECTION 1-1 1:75

FIG. b

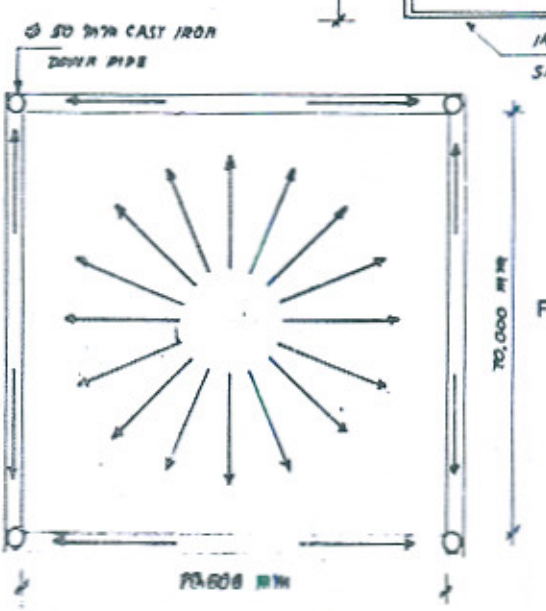
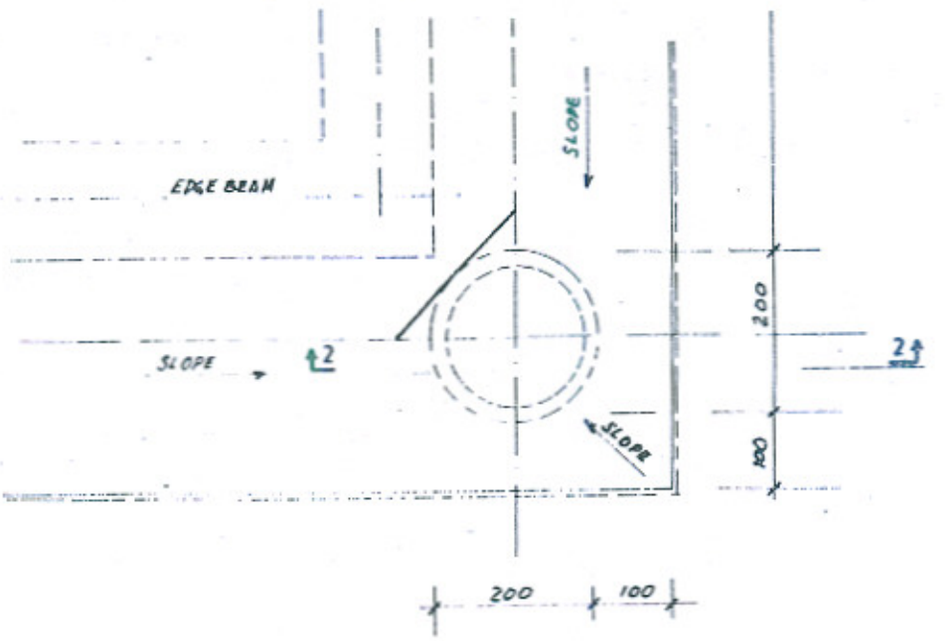
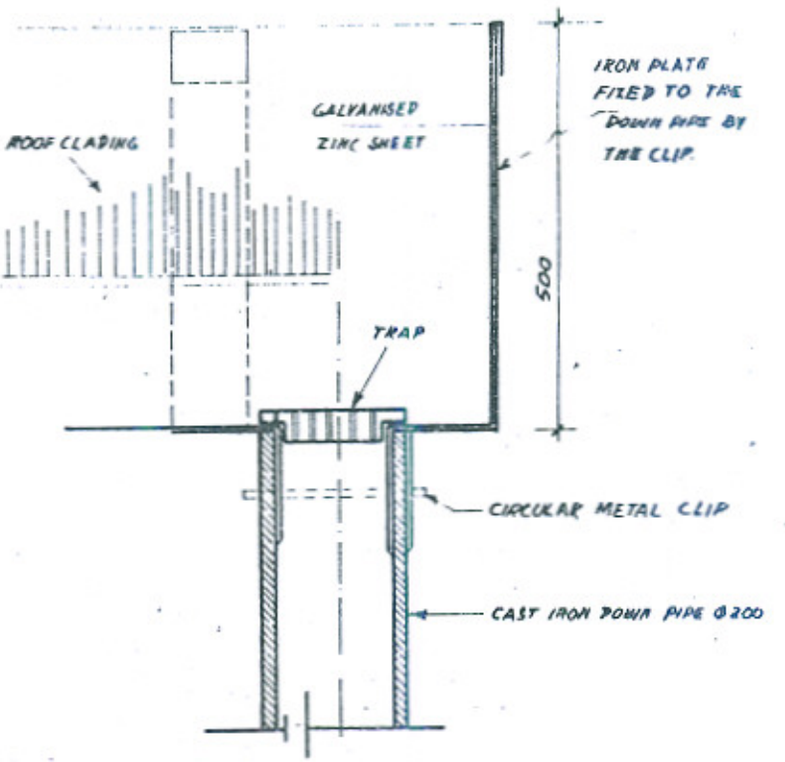


FIG. a

FIG. 3
DETAILS OF WATER DRAINAGE FROM ROOF OF DOME



PLAN AT CORNER 1:75



SECTION 2-2 1:75

FIG 4. DETAILS OF WATER DRAINAGE

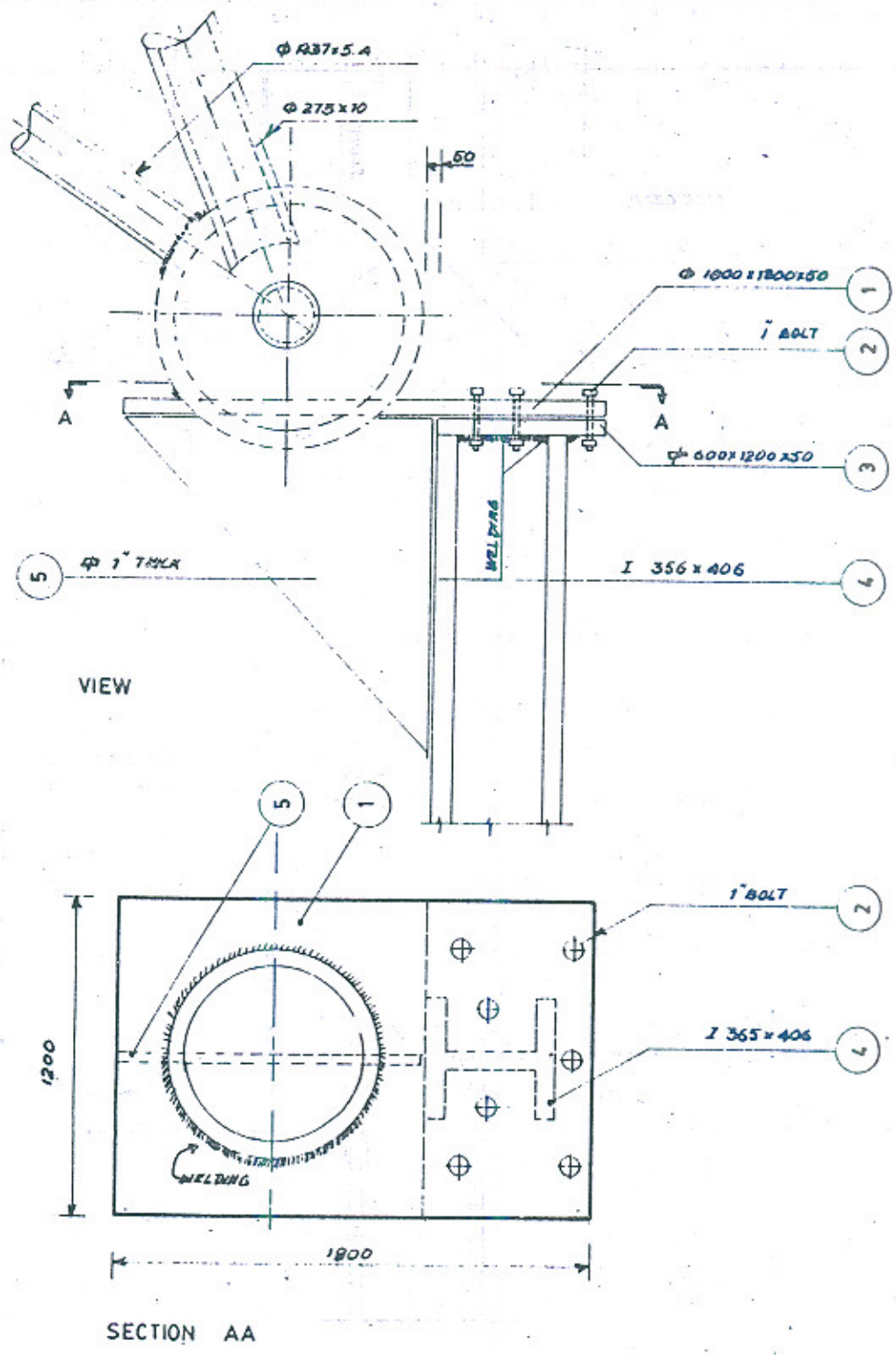


FIG 5. DETAILS OF CONNECTIONS AT SUPPORTS

پاکستانی انجنیئر جب کبھی بیرونِ ملک ملازمت کرتے ہیں تو اُن کی شہرت اچھی ہوتی ہے۔ امریکہ، یورپ، افریقہ، مشرقِ وسطیٰ، جہاں کہیں بھی پاکستانی انجنیئر گئے انہوں نے اپنی قابلیت کا سکہ جمایا۔ تو کیا وجہ ہے کہ پاکستان میں یہی انجنیئر کم مائیگی کا شکار ہو کر رہ جاتے ہیں۔ اِن کی چند وجوہ یہ ہیں:-

(i) انجنیئر کے لیے ترقی کے مواقع محدود ہیں۔ صوبائی محکموں میں حالات اِس قدر مخدوش ہیں کہ پچاس برس کی عمر سے پہلے گریڈ ۱۹ کی ترقی نہیں ملتی۔ واپڈا کے ڈھائی ہزار الیکٹریکل انجنیئرز کے لیے صرف ایک گریڈ ۲۱ کی آسامی ہے اور وہ بھی ابھی منظور کی گئی ہے۔ اتنے ہی کلاس I افسروں کے لیے غیر تکنیکی محکموں میں بیسیوں گریڈ ۲۱ اور کئی گریڈ ۲۲ کی آسامیاں ہیں۔ محدود آسامیوں کی وجہ سے انجنیئر آپس میں تگ و دو کا شکار ہو جاتے ہیں اور غیر انجنیئر اس کا فائدہ اٹھاتے ہیں۔

(ii) ترقی کی راہ مسدود ہونے کی وجہ سے تنخواہ میں اضافہ نہیں ہوتا۔ BPS کے گریڈوں سے لگاؤ کی وجہ سے انجنیئروں کو کوئی فائدہ نہیں ہوگا۔ اِس سلسلے میں وزارت پیداوار کے مینجمنٹ گریڈ اور دوسرے مینجروں کے گریڈوں سے کافی حد تک ازالہ ہو سکتا ہے اور انجنیئروں کے سلسلہ میں حکومت کو آپ کی وزارت کی تقلید کرنی چاہیے۔

(iii) ایوانِ حکومت میں انجنیئروں کی آواز نہ ہونے کے برابر ہے۔ انجنیئروں کے متعلق افواہوں کی تردید کرنے والے بہت کم ہیں۔ اس سلسلے میں ہمیں آپ کے تعاون کی ضرورت ہے کہ آپ وزارت میں انجنیئروں کی سربلندی کے لیے آواز اٹھائیں۔

اس سلسلے میں اراکین کانگریس سے بھی درخواست کروں گا کہ وہ اپنے ضابطۂ اخلاق کو قائم رکھیں۔ ہمیں اپنا کردار مثالی رکھنا ہوگا جو انجنیئروں کے شایانِ شان ہو تاکہ اِس شعبے کو بلند مقام و وقار حاصل ہو۔

جنابِ والا! پاکستان انجنیئرنگ کانگریس کو فخر حاصل ہے کہ آپ نے انتہائی مصروفیت کے باوجود ہمارے سالانہ اجلاس کا افتتاح کرنے کے لیے شرکت کی۔ آپ پہلے پاکستانی انجنیئر ہیں۔ جنہیں فوج میں لیفٹیننٹ جنرل کا عالی مرتبت عہدہ دیا گیا۔ یہ بھی خوش آئند ہے کہ تین اور انجنیئروں کو لیفٹیننٹ جنرل کے بلند عہدے پر ترقی دی گئی۔ پاکستان انجنیئرنگ کانگریس اِن تینوں صاحبان کو مبارک پیش کرتی ہے۔ کانگریس اُمید کرتی ہے کہ انجنیئروں کی خدمات کو تسلیم کیا جائے گا چاہے وہ فوجی ہوں یا غیر فوجی۔

جنابِ والا! میں آج کے معزز مہمانوں اور شرکاء کا شکریہ ادا کرتا ہوں جنہوں نے اپنا قیمتی وقت نکال کر کانگریس کے سالانہ اجلاس میں شرکت فرمائی۔

میں پاکستان انجنیئرنگ کانگریس کی ایگزیکٹو کونسل اور تمام ممبران کا شکریہ ادا کرتا ہوں جنہوں نے میرے ساتھ تعاون کیا۔ خاص طور پر جناب مشہدی صاحب کا شکریہ ادا کرتا ہوں جنہوں نے شاہراہ قراقرم سیمینار میں تندہی سے کام کیا۔ جناب ایوب شاہ کا بھی شکر گزار ہوں۔ اُن کی ہدایات میرے لیے مشعلِ راہ ہیں۔

اب میں جناب لیفٹیننٹ جنرل سعید قادر صاحب وفاقی وزیر برائے پیداوار سے درخواست کروں گا کہ پاکستان انجنیئرنگ کانگریس کے اٹھویں سالانہ اجلاس کا افتتاح فرمائیں۔

پاکستان پائندہ باد

سٹاف کو بھی مقرر کیا گیا ہے۔ امید ہے کہ یہ تربیتی ادارہ دیرینہ خلا کو پورا کرے گا۔

جناب والا! میں جب پاکستان اٹامک انرجی کمیشن سے منسلک تھا تو اس وقت ایک کوالٹی کنٹرول سیمینار میں جناب نے فرمایا تھا کہ ایک کوالٹی کنٹرول اتھارٹی قائم کی جانی چاہیے۔ اس سلسلے میں کوئی مثبت اقدامات نہیں کیے گئے۔ تعمیراتی کاموں کے گرتے ہوئے معیار کی سب سے بڑی وجہ تعمیراتی سامان ہے جس پر مؤثر کنٹرول نہیں ہے۔ یہ صورت حال صرف سول انجینیرنگ کے منصوبوں کی نہیں بلکہ بجلی کے سامان اور مشینری پر بھی لاگو ہے۔ بجلی کا پنکھا آپ کو چھ سو روپے کا ملے گا اور دو سو روپے کا بھی۔ عوام قدرتاً سستی چیز خریدیں گے۔ بجلی کی غیر معیاری موٹروں اور پنکھوں کی وجہ سے ہمارے بجلی کے نظام پر بہت زیادہ دباؤ پڑتا ہے۔ جو پاور فیکٹر کی کمی کی وجہ سے ہے۔ یہی حال تعمیراتی سامان کا ہے۔ بازار میں سستا مال خریدیں تو غیر معیاری ہوگا ادھر ہمارا ٹینڈر سسٹم اور فنانشل قواعد و ضوابط اس طرح ہیں کہ صرف کم قیمت والے کو ٹینڈر ملے گا اس سلسلے میں حکومت کو جلد از جلد کوالٹی کنٹرول اتھارٹی کا قیام عمل میں لانا چاہیے۔ دوسری طرف انجینیروں کو بھی چاہیے کہ اپنی تصریحات اس طرح ترتیب دیں کہ اس میں غیر معیاری سامان کی گنجائش ہی نہ رہے۔

انجینیر کا ایک اور بڑا فرض ٹرانسفر آف ٹیکنالوجی ہے تاکہ ملک انجینیرنگ میں خود کفیل ہو سکے۔ اس سلسلہ میں بہت ترقی ہو چکی ہے اور مزید کوشش کی ضرورت ہے۔ جناب والا! آپ کے زیر سایہ جو کارپوریشن کام کر رہی ہے انہوں نے خود کفالت کے لیے بہت کام کیا ہے۔ سیمنٹ اور چینی کے کارخانے یہیں بنائے جا رہے ہیں۔ کاروں کی اسمبلی اور بتدریج پروڈکشن کا کام ہو رہا ہے۔ کیمیاوی کارپوریشن بھی اپنے منصوبوں کی مشینری کا بیشتر حصہ یہیں بنا لیتی ہے۔ سول انجینیرنگ کے شعبہ میں اب یہ وثوق سے کہا جاتا ہے کہ ہر قسم کا منصوبہ پاکستانی انجینیر مکمل کر سکتے ہیں اور بیرونی ممالک کی امداد کی ضرورت نہایت ہی محدود طور پر محسوس کی جاتی ہے۔ لیکن بجلی اور مکینیکل انجینیرنگ کے شعبے میں ابھی ہم ترقی یافتہ ملکوں سے بیسیوں برس پیچھے ہیں۔ پاکستان میں ابھی تک بڑے پاور ٹرانسفارمر نہیں بنائے جاتے نہ ہی بڑے سرکٹ بریکر۔ بجلی گھروں کے بیشتر سامان کے لیے ابھی بھی ہم بیرونی ممالک کے مرہونِ منت ہیں۔ یہی حال بڑی انڈسٹری کی مشینری کا ہے۔ انجینیروں کو یہ چیلنج بھی قبول کرنا چاہیے۔

ٹرانسفر آف ٹیکنالوجی کے لیے سب سے زیادہ ضرورت مضبوط مشاورتی انجینیرنگ فرموں کی ہے یعنی CONSULTING ENGINEERING FIRMS اس سلسلہ میں نیسپاک کا نام کسی تعارف کا محتاج نہیں۔ انہوں نے اپنا لوہا دوسرے ملکوں میں بھی منوا لیا ہے۔ پرائیویٹ سیکٹر میں بھی مشاورتی انجینیرنگ ادارے گنے چنے ہیں۔ ضرورت تو یہ ہے کہ انہیں بھی پنپنے کا موقع دیا جائے اور نئے مشاورتی ادارے قائم کیے جائیں۔ چاہے وہ پبلک سیکٹر میں ہوں یا پرائیویٹ سیکٹر میں۔

جہاں تک غیر ملکی مشاورتی فرموں کا تعلق ہے ان کا تعین اُن قرضوں سے منسلک ہے جو ہمیں بین الاقوامی ادارے مہیا کرتے ہیں۔ انجینیر کا فرض ہے کہ ان غیر ملکی مشاورتی فرموں پر کم سے کم انحصار کریں اور جہاں کہیں بھی ان کا تعلق ایسی ٹیکنالوجی سے ہے جو ہمارے پاس میسر نہیں تو ان کے تجربے سے زیادہ سے زیادہ فائدہ اٹھایا جائے تاکہ دوبارہ ان کی ضرورت محسوس نہ ہو۔ مانگلا اور تربیلا کے بعد اب کالا باغ کے سلسلے میں ہمارا انحصار غیر ملکی مشاورت پر کافی کم ہو گیا ہے۔ یہ ایک خوش آئند بات ہے۔

جناب والا! پچھلے سال کے خطبۂ استقبالیہ میں یہ اپیل کی گئی تھی کہ آئندہ بڑے انجینیرنگ کاموں کی مشاورت اور تکمیل کے ٹھیکوں کے لیے یہ قانون وضع کیا جائے کہ جس شعبے میں پاکستان انجینیروں اور مشیروں کی صلاحیت موجود ہو اس میں غیر ملکی ماہرین اور ٹھیکیدار نہ بلائے جائیں۔ ثانیاً اگر کسی منصوبے کی تکمیل کے لیے غیر ملکی مشیر یا ٹھیکیدار لگانا ضروری ہو تو اُن میں پاکستانی مشاورتی فرمیں یا ٹھیکیدار باقاعدہ شریک ہونے چاہئیں۔ تاکہ ٹیکنالوجی ٹرانسفر ہو سکے۔ اس سلسلے میں پلاننگ کمشن نے بھی ایک کمیٹی قائم کی ہے۔ جو طریقہ کار وضع کرے گی۔ امید ہے اس کمیٹی کی سفارشات جلد ہی پیش کی جائیں گی۔

جناب والا! اب میں ایک نازک مسئلے پر انجینیروں کی توجہ مبذول کرتا ہوں۔ پاکستان میں انجینیروں کی ساکھ پہلے سے بہت کم ہو گئی ہے۔ جس کی وجہ سے ذہین طالب علم دوسرے شعبوں کو ترجیح دینے لگے ہیں۔ اچھے انجینیر پہلے حکومت کے دائرہ کار سے باہر ملازمت تلاش کرنے کی کوشش کرتے ہیں۔

۱۔ انجینئرنگ کے پروفیشن اور پریکٹس کو فروغ دینا۔
۲۔ ممبران کانگریس کو پروفیشنل معاملات پر بحث و تمحیص کا موقع فراہم کرنا۔
۳۔ ایسا ضابطۂ اخلاق قائم کرنا۔ جو ممبرانِ کانگریس کی کارکردگی میں مددگار ہو۔

کانگریس کے ہر سالانہ اجلاس میں انجینئرنگ کے مختلف شعبوں سے متعلق مختلف منصوبوں اور دوسرے تکنیکی معاملات پر مقالے پڑھے جاتے ہیں اور زیر بحث لائے جاتے ہیں۔ اس ضمن میں اب تک چار سو ستاون مقالے پڑھے جا چکے ہیں اور موجودہ اجلاس میں بھی دس مقالے پیش کیے جا رہے ہیں۔ پچھلے بہتر برس میں پیش کیے جانے والے مقالے انجینئرنگ کا ورثہ ہیں۔ کوئی بڑا تعمیراتی منصوبہ ایسا نہ ہوگا جس پر مقالہ نہ پڑھا گیا ہو۔ اس میں اہل ہائیڈرو الیکٹرک پراجیکٹ بھی شامل ہے اور دریائے شیوک کی طغیانی بھی جو گلیشیر کے سرکنے کی وجہ سے ہوئی۔ تبت تک سڑک بنانے کے فرضیاتی منصوبے پر بھی مقالہ لکھا گیا۔ کانگریس کے مقالے تاریخی مقام رکھتے ہیں اور کانگریس کا ارادہ ہے کہ ان تمام مقالوں کا MICRO-FICHE بنایا جائے جسے پاکستان اور بیرونی ممالک کی مشہور لائبریریوں میں رکھا جائے۔ اِس قسم کی ایک درخواست امریکن لائبریری سے پہلے ہی موصول ہو چکی ہے۔

کانگریس کے سالانہ اجلاس کی روائت یہ بھی ہے کہ اس کے اختتام پر مختلف منصوبوں کے مشاہدے کے لیے دورے کا بندوبست کیا جاتا ہے جس کے لیے پاکستان ریلوے ایک سپیشل ٹرین کا اہتمام کرتی ہے اِس مرتبہ بھی ایک سپیشل ٹرین چلائی جا رہی ہے اور اراکین کانگریس اسلام آباد میں کیپٹل ڈویلپمنٹ اتھارٹی کے منصوبے دیکھیں گے۔ بعد میں ٹیکسلا کے ہیوی مکینکل کمپلیکس اور ہیوی فورج اور فونڈری کا معائنہ کریں گے جن کا اہتمام آپ کے زیر سایہ ہے کانگریس کے اراکین کامرہ کمپلیکس اور پشاور کے چند منصوبے بھی دیکھیں گے۔

جنابِ والا! کانگریس کی صدارت کا عہدہ سنبھالتے وقت میں نے کہا تھا کہ کانگریس کی کارروائی سالانہ اجلاس تک محدود نہیں ہونی چاہیے۔ اور ششماہی سیمینار بھی منعقد ہونے چاہئیں۔ کانگریس کا پہلا ایسا سیمینار نومبر میں راولپنڈی میں منعقد کیا گیا جس میں شاہراہ قراقرم اور شمالی علاقوں کے دوسرے منصوبوں پر مقالے پڑھے گئے۔ یہ سیمینار نہایت کامیاب رہا۔ اور ہمارے انجینئروں کو ایک ایسے منصوبے سے روشناس کرایا گیا جو دنیا کا آٹھواں عجوبہ تصور کیا جاتا ہے اس سیمینار کے اختتام پر قریباً پچاس انجینئروں کی جماعت شاہراہ قراقرم کے دورے پر روانہ ہوئی اور انتہائی سردی کے باوجود قریباً خنجراب پاس تک پہنچی میرے لیے انجینئروں کا یہ دورہ ایک دیرینہ خواب کی تکمیل تھی۔

ایک اور سیمینار TILE-DRAINAGE کے موضوع پر سکھر میں کیا جائے گا۔ اس سیمینار کی تاریخ کا تعین اگلی کونسل کرے گی۔

اِسی سال کے دوران آئین کمیٹی نے "بائی لاز" کو از سرِ نو تشکیل دیا ہے جو کونسل سے منظور کروانے کے بعد شائع ہو چکے ہیں۔

یہ بھی فیصلہ کیا گیا تھا کہ پاکستان انجینئرنگ کانگریس کی تاریخ عام فہم زبان میں شائع کی جائے۔ یہ کام جناب مشہدی صاحب کو سونپا گیا تھا لیکن ٹیڈیل کام ہے اور اس میں ابھی چند ماہ درکار ہوں گے۔

جنابِ والا! کسی ملک کی اقتصادی ترقی اُس کے انجینئروں کی مرہونِ منت ہے۔ انجینئر دیگیانوں کو لہلہاتے ہوئے کھیتوں میں تبدیل کر دیتے ہیں۔ پگڈنڈیوں کو شاہراہیں بنا دیتے ہیں۔ دُور دراز علاقوں میں رہ کر منصوبے مکمل کرتے ہیں۔ انجینئر قوم اور معاشرے کی بہتری کے لیے نظریات کو عملی شکل دیتا ہے۔ انجینئر بننے کے لیے قریباً سولہ سال کی تعلیم کی ضرورت ہوتی ہے جو دوسرے شعبوں سے قدرے مشکل ہے اس تعلیم کے بعد تربیت اشد ضروری ہے۔ تربیت کی اہمیت کو اب تسلیم کیا گیا ہے۔ آپ کے زیر سایہ جتنے بھی منصوبے ہیں اُن میں تربیتی سکول قائم کیے گئے ہیں۔ خاص طور پر پاکستان سٹیل میں۔ کانگریس نے بھی اِس سلسلے میں اپنا کردار ادا کیا ہے اور کانگریس کی تحریک پر حکومتِ پنجاب نے ٹھوکر نیاز بیگ کے مقام پر "انجینئر اکادمی" قائم کی ہے۔ اس کی عمارت مکمل ہو چکی ہے۔ میاں خلیل الرحمٰن، جو انجینئرنگ میں اعلیٰ مقام رکھتے ہیں اُن کا تقرر بطور پرنسپل کیا جا چکا ہے۔ اس کے علاوہ دوسرے

خطبۂ استقبالیہ

بسم اللہ الرحمٰن الرحیم

محترم لیفٹیننٹ جنرل سعید قادر صاحب

وفاقی وزیر برائے پیداوار

مہمانانِ گرامی، ممبران پاکستان انجینئرنگ کانگریس!

خواتین و حضرات



انجینئر داؤد بیگ

السلام علیکم:-

میرے لیے فخر کا مقام ہے کہ میں آج اس پلیٹ فارم سے آپ سب کو پاکستان انجینئرنگ کانگریس کی انسٹھویں سالانہ اجلاس کے موقع پر خیر مقدم کر رہا ہوں۔ یہ کانگریس ۱۹۱۲ء میں قائم ہوئی اور برصغیر میں انجینئروں کی پہلی پیشہ وارانہ تنظیم تھی۔ اسی کانگریس کے صدر ایسے نامور انجینئر رہ چکے ہیں جن کے ماتحت کام کرنے کا ہم میں سے بہتوں کو فخر حاصل ہے۔

اس کانگریس کے پہلے صدر سر ایچ۔ پی۔ برٹ تھے۔ دوسرے صدر کرنل میکلیگن جن کے نام پر لاہور کے انجینئرنگ کالج کی بنیاد رکھی گئی۔ ۱۹۲۳ء میں سر گنگا رام اس کانگریس کے صدر تھے۔ اُن کا نام رفاہی ہسپتالوں اور اداروں سے منصوب ہے۔ یہ کم لوگوں کو علم ہے کہ وہ ایک مشہور انجینئر بھی تھے۔ ریناله کی لفٹ ارگیشن سکیم انہی کا کارنامہ ہے آزادی سے پہلے اسی عہدے پر ایکمین، منٹگمری، والٹن، گریفن بھی فائز رہے جن کے نام سے ریلوے ٹریننگ سکول، سڑکیں اور دوسرے ادارے منصوب ہیں۔ ڈی۔ اے۔ ہاول انجینئرنگ کالج لاہور کے پرنسپل تھے۔ انہوں نے مری کی واٹر سپلائی سکیم اور ڈونگا گلی سے کلڈنہ تک پائپ لائن اور اس کا راستہ تعمیر کیا۔ جو نصف صدی کے بعد آج بھی مری کی ضروریات پوری کر رہا ہے۔

معزز مہمانِ گرامی! آزادی کے بعد بھی پاکستان انجینئرنگ کانگریس کو نمایاں مقام حاصل رہا۔ اور پاکستان کے بہت سے نامور انجینئر اس کانگریس سے منسلک رہے ہیں۔ خان بہادر اعظم، خواجہ غفور، خان بہادر حمید، شیخ محبوب کانگریس کے صدارتی فرائض انجام دیتے رہے اور انہوں نے اس میں نئی زندگی پیدا کی۔ ڈاکٹر مبشر حسن نے کانگریس بلڈنگ کی تعمیر میں نمایاں کردار ادا کیا۔ جناب والا، میں نہایت انکساری سے ان سب عظیم انجینئروں کو ہدیۂ تہنیت پیش کرتا ہوں۔

پاکستان انجینئرنگ کانگریس کا تعلق شروع سے ہی سول انجینئرنگ کے شعبہ سے رہا۔ آزادی کے بعد کانگریس میں انجینئرنگ کے دوسرے شعبوں کو بھی اہمیت ملی۔ اور چند ایسے انجینئروں کو بھی صدر کے عہدے کے لیے منتخب کیا گیا جن کا تعلق سول انجینئرنگ کے ساتھ نہ تھا اس وجہ سے صدارت کا اعزاز میرے لیے اور بھی باعثِ فخر ہے اور آپ کو خوش آمدید کہتے ہوئے یہ بھی خوشی ہے کہ آپ کا تعلق بھی ای۔ ایم۔ ای سے ہے۔ جو کانگریس کے وسیع تر حدود کا آئینہ دار ہے۔

جنابِ والا! کانگریس کے اغراض و مقاصد بالکل تکنیکی ہیں۔ اس میں سیاست کا ذرہ بھر عنصر نہیں ہے۔ کانگریس کے چیدہ چیدہ اغراض و مقاصد اس طرح ہیں:-

٥۔ وَلَا تَأْكُلُوٓا أَمْوَالَكُمْ بَيْنَكُمْ بِالْبَاطِلِ وَتُدْلُوا بِهَا إِلَى الْحُكَّامِ لِتَأْكُلُوا فَرِيقًا مِّنْ أَمْوَالِ النَّاسِ بِالْإِثْمِ وَأَنتُمْ تَعْلَمُونَ ۝

"And swallow not up your property among yourselves by false means, nor seek to gain access thereby to the judges, so that you may swallow up a part of the property of men wrongfully while you know". ii : 18

5. You shall not abuse your position or power, nor accept illegal gratification of any sort.

٦۔ وَقُولُوا قَوْلًا سَدِيدًا ۝

"And speak straight words." xxxiii : 70

6. You shall express your opinion on engineering or other matters in a frank, open and straightward manner.

٧۔ اجْتَنِبُوا كَثِيرًا مِّنَ الظَّنِّ إِنَّ بَعْضَ الظَّنِّ إِثْمٌ وَلَا تَجَسَّسُوا وَلَا يَغْتَب بَّعْضُكُم بَعْضًا

"Avoid most of suspicion for surely suspicion in some cases is sin ; and spy not nor let some of yon backbite others". xlix : 12

7. You shall not criticise another engineer's work without his knowledge, nor malign, or injure his pressional repultation.

٨۔ وَلَا تَقْفُ مَا لَيْسَ لَكَ بِهِ عِلْمٌ إِنَّ السَّمْعَ وَالْبَصَرَ وَالْفُؤَادَ كُلُّ أُولَٰئِكَ كَانَ عَنْهُ مَسْئُولًا ۝

"And follow not that of which thou hast no knowledge. Surely the hearing and the sight and heart, of all these it will be asked." xvii : 36

8. Your professional advice shall be based on full knowledge of the facts and honest conviction, and you shall not write articles or advertise in self-laudatory language or in any manner derogatory to the dignity of the profession.

٩۔ وَتَعَاوَنُوا عَلَى الْبِرِّ وَالتَّقْوَىٰ ۖ وَلَا تَعَاوَنُوا عَلَى الْإِثْمِ وَالْعُدْوَانِ ۚ وَاتَّقُوا اللَّهَ

"And help one another in righteousness and piety. and help not one another in sin and agression and keep your duty to God". v : 2

9. You shall help one another in upholding and doing what is right, and shall not associate with those who transgress and those who indulge in unethical practices.

١٠۔ وَأَمْرُهُمْ شُورَىٰ بَيْنَهُمْ ۖ

"And whose affairs are decided by counsel among themselves". xlii : 38

10. You shall decide matters of common professional interesty by mutual consultation.

١١۔ وَاعْتَصِمُوا بِحَبْلِ اللَّهِ جَمِيعًا وَلَا تَفَرَّقُوا ۚ

"And hold fost by the covenant of God all together and be not disudited". iii : 102

11. You sholl strive individully and collectively to enhance the prestige of the engineering profession by ordering your canduct in accordance with this Code of Ethics and shall not be disunited.