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24TH ISSUE, 1980-81

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THE CIVIL ENGINEER

24th ISSUE 1980-'81

EDITED BY :

RUPAK SARKAR

Gram : TECHNICS

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सत्यमेव जयते

BENGAL ENGINEERING COLLEGE
HOWRAH-711103

MESSAGE

I am happy to learn that the Society of Civil Engineers of the College is bringing out its annual technical journal, "The Civil Engineer" in January 1981.

The journal as the mouthpiece of the students of the Department of Civil Engineering of the College has been serving the cause of Civil engineering and Civil engineers by disseminating knowledge of this very old engineering discipline. I have no doubt that the present 24th issue of the Annual Number will continue to foster the growth of the healthy tradition which it has so assiduously built up over the past so many years.

On this auspicious occasion, I congratulate the members of the editorial board of the journal for their untiring pains in bringing out this publication and also take this opportunity to reach my students in the Department in wishing them all the best.

Sd/-
A. K. Seal.
Principal,
Bengal Engineering College.

ngc/15. 12. 80

THE ANNUAL TECHNICAL PUBLICATION

24TH ISSUE

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DR. SURESH P. BRAHMA,
PROFESSOR & HEAD,
CIVIL ENGINEERING DEPARTMENT,
BENGAL ENGINEERING COLLEGE.

MESSAGE

20th December, 1980.

It is heartening to note that the Society of Civil Engineering students, B. E. College, is ready with their 24th issue of their annual magazine "The Civil Engineer". The scope of civil engineers is ever increasing and this issue focuses the awareness of civil engineering students about their profession. I would hope that this issue apart from providing the enthused students an opportunity to express their thoughts will bring the best out of the not so enthused students. It is the responsibility of all civil engineers to see that forums to express thoughts of young engineers are kept alive as they help in healthy growth of the profession and of our nation.

I extend my greetings to the members of the Society of civil engineering students and wish the organisers a grand success.

Sd/-
Suresh P. Brahma
President
Society of Civil Engineers,
Bengal Engineering College.

ACKNOWLEDGEMENT

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S. K. ROY
B.E. (Cal.), M.S. (U.S.A.), F.I.E. (Ind.)
Director General of Planning & Development
Calcutta Metropolitan Development Authority.

MESSAGE

I am glad to learn that the Society of Civil Engineers of Bengal Engineering College is publishing its twenty-fourth annual technical Journal, The Civil Engineer.

The Society of Civil Engineers, a professsional organisation of the Students of Civil Engineering, has a great role to perform in creating professional attitude amongst the future engineers. The engineers to-day are to perform developmental tasks in the nation-building activities, Contributing towards social, economic and physical prosperity The society is a forum of expression and mode of exchange of ideas in this great task.

I wish the society and the Civil Engineers all success.

Sd/-
S. K. Roy
6. 12. 80.

The staff and students of our department deeply regret the void left in the faculty by the retirement of :

Dr. S. K. MUKHERJEE

AND

Prof. S. K. BHATTACHARYA

We hope that the magnanimity of our patrons will pardon our minor discrepancies which may have escaped our notice or caused during printing and the rectification of which was not possible as we raced against time.

The Society is not responsible for the statements made by the authors of papers published in the journal, nor of the claims made by the advertisers.

—Editor

Editorial

The process of education should be such that the students gain familiarity with problems in the immediate vicinity and the manner in which one might look for a solution based on an understanding of nature and its laws and making full use of existing human knowledge. For proper discussion of knowledge and the latest techniques with a view to avoid undue wastage of resources and duplication of effort and for interchange of ideas amongst its readers with a view to attain economy and efficiency in operations of industries and constructional jobs "THE CIVIL ENGINEER" is being launched.

These types of journals are a must in order to enable the students to cultivate a highly technical outlook and bring their technical ideas to limelight. Behind this successful publication lies the tiresome efforts of our students, the guidance and active help of our professors and the financial support from our patrons, to maintain the traditional glory of the 124 years old department.

The issue has invariably been enriched by the contributors from the engineers who are experts in their respective fields. It also reflects the thinking and imaginative power of the budding civil engineers. Thus we are aiming squarely with blooming engineers and partly with professionals. Hoping that this publication remains a testimonial of its value, I want to express my gratitude to all those who had co-operated with us to tide over all the difficulties faced in this publication.

The benefit that the readers will derive from that journal will be our reward for publishing it.

Rupak Sarkar
(*Final Year*)

CONTENTS

A SIMPLE PROGRAMME FOR CANAL DESIGN

Dr. Suman Dasgupta

Computers are being increasingly used for obtaining numerical solutions of various engineering problems Special computer-oriented numerical methods have been developed for such purpose. However, in many cases, traditional approaches or algorithms as are used for manual computation, may be used as the basis for writing computer programmes. Only a little familiarity with a programming language like FORTRAN, which is acceptable to almost all the computer systems, would be necessary for preparing such programmes. One such simple programme, in FORTRAN, for canal design is presented below, along with the associated flow chart.

The basic steps for the design of a canal by a trial and error procedure are :—

1) The values of the following parameters are known or are assumed to be knon ;

   h is Side slope (horizontal / vertical),

   Q is Discharge (cumec),

   N is Manning's coefficicnt,

   S is Bed slope (vertical / horizontal),

   Sn and C are constants depending on the soil.

   The object of design is to find suitable values of bed width, b, and depth of the canal, d.

2) Assume a trial value of d.

3) Calculate the following

   Critical velocity, $v_0 = cd^{sn}$

   Area, $A = Q/V_0$

   Bed width, $b = \frac{A}{d} - hd$

   Hydraulic mean radius, $R = \frac{A}{b+2d\sqrt{1+h^2}}$

   Velocity, $V = \frac{1}{N} R^{2/3} S^{1/2}$

4) Check by comparing V and V_0

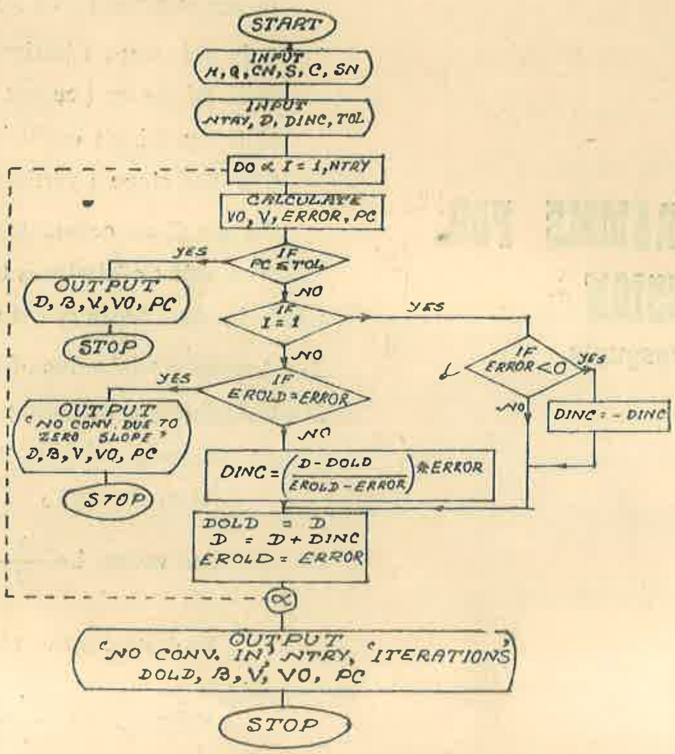
   a) If $V = V_0$, the design is O. K.

   b) If $V > V_0$, increase the value of d for a fresh trial (Start from step 3).

c) If $V \angle V_o$, decrease the value of d for a fresh trial (Start from step 3).

The operations are to be repeated until the values of V and V_o agree within a reasonable limit.

In the programme presented, the permissible value of the tolerance in percentage, within which V_o and V must agree, is designated TOL, while the maximum number of iterations is termed NTRY. These values, as well as the initial assumed value of the depth, D, and the next increment in its value, DINC, in case the first trial does not produce satisfactory results, are fed as input to the programme. For trial, successive values of increment of depth are calculated by linear extrapolation (secant method). In the programme, the variable ERROR designates the difference ($V - V_o$) and PC designates lhe percentage variation between V and V_o, and is equal to $\frac{| V - V_o |}{V_o} \times 100$.



FLOW CHART FOR CANAL DESIGN

```
      PROGRAM CANAL DESIGN
      READ ( 7, 101 ) H, Q, CN, S, C, SN
      WRITE ( B, 101 ) H, Q, CN, S, C, SN
101   FORMAT ( 6 F 10.4 )
      READ ( 7, 102 ) NTRY, D, DINC, TOL
102   FORMAT ( I5, 3 F 10.4 )
      DO 2 I=1, NTRY
      VO = C * D * * SN
      A = Q/VO
      B = A/D - H * D
      R = A/( B + 2. * D * SQRT ( 1. + H * * 2 ) )
      V = R * * ( 2. / 3. ) * SQRT ( S ) / CN
      ERROR = V-VO
      PC = ABS ( ERROR ) / VO * 100.
      IF ( PC. GT. TOL ) GO TO 3
      WRITE ( 8,103 ) D, B, V, VO, PC
103   FORMAT ( //5X, 'D= ', F 10·4, 'B= ', F 10·4, 'V= ',
    1 F 10·4, 'VO= ,' F 10·4' 'PC= ,' F 10·4 )
      STOP
3     IF ( 1.EQ.1 ) GO TO 4
      IF ( EROLD.NE.ERROR ) GO TO 5
      WRITE ( 8,104 ) D, B, V, VO, PC
104   FORMAT ( //5X, 'NO CONV. DUE TO ZERO SLOPE', 5F10·4 )
      STOP
5     DINC = ERROR * ( D-DOLD ) / ( EROLD-ERROR )
      GO TO 6
4     IF ( ERROR.LT.O.O ) DINC = -DINC
6     DOLD = D
      D=D + DINC
      EROLD = ERROR
2     CONTINUE
      WRITE ( 8,105 ) NTRY, DOLD, B, V, VO, PC
105   FORMAT ( //5X, 'NO CONV.IN', I5, 'ITERATIONS', 5F 10·4
      STOP
      END
```

Acknowledgement :—

The author is indebted to his colleague Prof. Tapan Kumar Dutta who presented the problem to him and urged to prepare a programme for solving it

Equation of EQUATION OF TIME

Dr. Pradip K. Ray,
Asst. Prof. Civil Engg. Dept.,
B. E. College.

The motion of apparent sun is not uniform througout the year, and the inconvenience caused finally evolves the mean sun concept for the civil time. The difference, numerically the apparent time MINUS the mean time, is termed as the equation of time and published in the almanac in tabular form.

The two basic reasons of the difference are (a) obliquity of ecliptic, and (b) non-uniformity due to the elliptic path of apparent sun. Consequent equation of time is a combination of two wavy patterns, one of full-year cycle and another of half-year cycle. Assuming the waves to be of sine form and convert ing the phase-lag into amplitudes with a cosine term, the equation of equation of time may be taken as, $e = A \sin mt + B \cos mt + C \sin 2mt + D \cos 2mt$. where, m may be taken as $360/(365+0{\cdot}25-0{\cdot}01+0{\cdot}0025)$, averaging effects of leap years excluding centuries and including fourth century, t may be expressed by the daynumber with value O at Zero hour of first January, the angles being thus expressed in degrees, e may be conveniently expressed in decimal minutes. The unknowns A, B, C, D may be evaluated with four values from the almanac, and better expressions will be obtained by increasing degrees of freedom needed for least-suqares solution.

A few numerical values of e for different t's during 1978, are given in table 1.

Table 1. E. T. During 1978

Serial No.	Universal Time Month	Date	Time	Equation of Time	Remarks	t day	e minute
1	Jan	1	0h 0m	-3m 16·1s		0	−3·27
2	Apr	2	6-0	-3m 43·7	Equal	91·25	−3·73
3	July	3	12-0	-4m 5 0	Interval	182·50	−4·08
4	Oct	1	18-0	+10m 18·8		273·75	10·31
5	Apr	15	21h 20m	0		104·89	0·0
6	Jun	14	23-15	0	Null	163·97	0·0
7	Sep	1	17-14	0	points	243·72	0·0
8	Dec	25	13-22	0		358·56	0·0
9	Feb	11	9h	−14m 16·9s	Approx	41·37	−14·28
10	May	14	15	+3m 43·7	trough	133·62	3·73
11	July	26	18	−6m 26·9	or	206·75	−6·45
12	Nov	3	22	+16m 23·6	peak	306·50	16·39
13	Dec	31	24-0	−3m 9·4s	end	365	−3·16

The first eight points in the table are taken, the condition equations framed and normalized to the following four equations :

$$+3.8123\,A-0.2010\,B-1.3514\,C-0.2703\,D=-14{\cdot}04$$

$$-0{\cdot}2010\,A+4.1855\,B+0.0158\,C+0.6600\,D=+\ 0.81$$

$$-1{\cdot}3514\,A+0{\cdot}0158\,B+1{\cdot}3550\,C-0{\cdot}7412\,D=0{\cdot}00$$

$$-0{\cdot}2703\,A+0{\cdot}6600\,B-0{\cdot}7412\,C+6{\cdot}6331\,D=-13{\cdot}93$$

The results being, A = −7·69 min, B = +0·65, C = −10·40, D = −4·99, with the standard deviation of 1 33 mins. The values when put in points 9 to 12, yield a maximum error of 2·1 min with RMS 1·7 minutes.

The inclusion of maxima and minima points in the normalized equations and suitable re-arrangement for fast convergence in successive iterations give the following forms :

$$D = -0{\cdot}0003\ B + 0{\cdot}0216\ A - 0{\cdot}0546\ C - 3{\cdot}81$$

$$B = +0{\cdot}0450\ A - 0{\cdot}0417\ C - 0{\cdot}0004\ D + 0{\cdot}33$$

$$A = +0{\cdot}1728\ C + 0{\cdot}0278\ D + 0{\cdot}0501\ B - 5{\cdot}61$$

$$C = -0{\cdot}0854\ D - 0{\cdot}0565\ B + 0{\cdot}2100\ A - 7{\cdot}99$$

Three iterations are made to get the results, $D = -3{\cdot}46$, $B = +0{\cdot}39$, $A = -7{\cdot}29$, $C = -9{\cdot}25$ with a standard deviation of only 0·18 min, i.e, 10 secs. When used in point no. 13, the yearend the equation of time becomes $-2{\cdot}98$ mins showing 10 secs error.

The resulting equation of 'EQUATION OF TIME' is, therefore,

$$e = -7{\cdot}29 \sin k + 0{\cdot}39 \cos k - 9{\cdot}25 \sin 2k - 3{\cdot}46 \cos 2k,$$

Where e is in minutes, and k, in degrees $= 0{\cdot}9856465t$, the time-argument t being the daynumber with Zero-hour UT of first January as epoch.

Reference : The Star Almanac for Land Surveyors for the year 1978, H. M. S. O., London.

"They are never alone that are accompanied with noble thought"

—Phlip Sydney.

A Comparative Study of Methods of evaluation of Coefficient of Uniform elastic Compression

Prof. B. C. Chattopadhayay. B. E. College

Introduction :

One of the most important parameters required for design of foundations subjected to dynamic loads, is the Coefficient of uniform elastic compression (c_u) or the spring constant (k) for the supporting medium, Evaluation of either one of them insitu condition is of prime importance for a realistic study of the response of the machine-foundation-soil system to the dynamic loads transmitted to the system due to operation of the machines. Mathematically these two parameters are related to each other by the following expression :
K=Cu A, where A=Base Contact Area of the foundation. Thus estimate of one of these parametres will suffice for machine foundation analysis.

Two basic design criteria of the machine foundation are : (i) Natural frequency of the machine-foundation-soil system should be sufficiently different from the operating frequency to avoid resonance.

and (ii) Amplitude of vibration should be within the permissible limit which may be different for different tolaration conditions.

In vertical mode of vibration, either of these parameter plays a vital role in determining the natural frequency and its amplitude of vibration. There are several methods available for evaluation of these parameters. In one of these approaches, Cu or K can be estimated from the value of elastic constants E, G or μ of the supporting soil, from the relationships between them derived from elastic theory, like

$$k=\frac{4G}{1-\mu}.R \text{ for circular footing of radius R} \quad ......(1)$$

$$\text{or}=\frac{2G\,\beta_v}{1-\mu}\sqrt{LB} \text{ for rectangular footing of size } L\times B...$$

(After Richant etal 1970) (2)

where G=shear modulus

$$=\frac{E}{2(1+\mu)}$$

E=Young's Modulus of soil

μ=Poisson's Ratio

β_v=Factor dependant on L/B ratio

=1 for squre footing

From Equations (1) or (2) , K can be estimated if any two of elastic constants are known.

Values of G or E can be estimated form laboratory test on undisturbed samples collected from the site or in-situ–field tests.

Evaluation of Elastic characteristics in field

Indian standard IS5249 recommends steady state vibration test or Hammer test for evaluation of elastic and shear modulus of soil. In the first case, wave length (X) of propagating vibrations caused by the steady state excitation of a model block at certain frequency, is measured by noting the distance (x/4) between adjascent points with arriving waves with phase difference of (1.57). Velocity of shear wave V_s is determined from the wave length (X). Elastic and shear modulus are determined from the following experessions :

$$E = 2dv_s^2 (I+\mu) \quad \ldots(3)$$

$$G = v_s^2 d \quad \ldots(4)$$

where d=Mass density of soil.

In hammer test, average velocity of compression wave (V_c) produced by the impact of a freefalling hammer is determined by noting the distance between the source and point of observation. Then elastic modulus E can be estimated as,

$$E = V_c^2 d \frac{(I+\mu)(1-2\mu)}{(1-\mu)} \quad \ldots(5)$$

From the equations (3),(4) and(5), it is evident that E or G can only be determined provided value of μ is known. Actual evaluation of μ is extremely difficult and doubtful, and the value of μ is generally assumed.

Evaluation of Elastic characteristics from Cyclic Triaxial Test :

Following the method adopted by Wilsan and Dietrecli (60) elastic modulus (E) can be evaluated by repeated cyclic triaxial tests on undisturbed samples collected from the site at required depth. In this test, samples are subjected to confining pressure as near as possible to the confining pressure under working condition. The sample is then subjected to an axial stress equal to the static stress equal to the working condition positive and nagative value of a small increment of load is applied to the sample, and the process is repeated till additional axial strain per cycle becomes unifrom. At that condition,

$$E = \frac{\text{Change in unit stress}}{\text{Corresponding change in unit deformation}}$$

Evaluation of Spring Constant 'k' in the field test

One of the widely used test method for evaluation of K or C_u is block vibration test. In this test, a concrete block is constructed in a suitable pit of depth equal to the proposed foundation depth. Exciting the foundation in vertical mode at different frequency the amplitudes of vibrations are recorded and response curve is plotted. Natural frequency (f_u) of the system is evaluated from the plot at resonance condition and C_u is evaluated from the following relation.

$$Cu = \frac{4 \times (3{\cdot}14)^2 fu^2 . M}{A} \quad \ldots\ldots(6)$$

where M=Mass of the oscillator, block and motor
A=Contact area of the block with soil.

The other method which is recommended by Barkan (62) and also advocated by IS–5249-77, is cyclic plate load test. In such test, coefficient of uniform elastic compression is obtained as the slope of the straight line relationship of the plot between elastic part of settlement and applied pressure.

As discussed above, several methods are available to evaluate 'K' or Cu, and each method has its own limitation. However, there are little data available to examine the validity of all such methods as from the actual response of the constructed machine foundation. Here an attempt has been made to evaluate (Cu) for a particular base contact area at same site by three different methods, namely, shear wave velocity method, repeated cyclic triaxial test on undisturbed samples collected from the site and block vibration test on a model block made at the site.

TESTING DETAIL AND TEST RESULTS

A test pit of size 6m × 2.75m at the bottom and depth equal to proposed depth of foundation of 2m was made at the site. A plain cement concrete block of M-150 concrete of size 1m × 1m × 0.75m was constructed within the pit with symmetrical positioning. After curing the block for 21 days, block vibration test was performed on this block. Wave propagation test for determining of shear modulus was also performed same pit, at the end of the block vibration test. Undisturbed soil samples were collected from the foundation level, sealed properly and transported to the Civil Engineering Laboratory for triaxial cyclic test.

From the vertical resonance test on the block, average resonance frequency obtained was 32 CPS, while the base contact area = 100 × 100 = 10000 cm^2.

Also Mass of the block, exciter and the motor was 1 782 So from equation (6)

$$C_u = \frac{4 \times 3.14^2 \times 1.782^2}{10000} \times 32^2$$

$$= 7.197 \text{ kg/cm}^3$$

From the wave propagation test at the siie in the pit, average velocity of shear wave was 18800 Cm/sec. while mass density of the soil was found to be 0.00196 gm-sec^2/cm^4. Thus values of E and G are given by,

$G = PV^2_s = 691.6$ kg/cm^2

$E = 2G(1+\mu) = 1867.3$ kg/cm^2 where μ assumed to be 0.35

From cyclic triaxial test on undisturbed samples collected from the pit, under different confining pressures, following results were obtained :—

Confining pressure	Values of E kg/cm^2
0.5	234
1.0	207
2.0	195
2.5	221
3.0	245
4.0	273

Average value of E = 229 kg/cm^2

From thd determined value of E or G as above, value of Cu for the area 1 m × 1 m (i.e, equal to base contact area of the block vibration test) was evaluated, as

$$Cu = \frac{2G}{(1-\mu)\sqrt{A}}$$

The values obtained for Cu for base contact area of 1m^2 from the above three methods, are given below :

Vertical Resonance Test	Shear Modulus Test	Cyclic Triaxial Test
7.197 kg/cm^3	21.28 kg/cm^3	2.61 kg/cm^3

Conclusion

As seen above, the value of coefficient of uniform elastic compression, evaluated by the 3 different methods yields widely divergent results. Shear modulus test procedure leads to a very large value and the triaxial cyclic test leads to a very low value of Cu compared to that obtained from vertical resonance test on model block at the site. Since the last mentioned test simulates the actual machine foundation performance, it is felt that Cu must be evaluated from model block Vibration test and results of other tests as mentioned should not be used for design of such machine foundation to avoid over-safe or under-safe design.

The repeated cyclic test indicates very conservative values for Cu, and therefore if such Cu values are adopted, will yield very uneconomic design. However, repeated cyclic triaxial tests can be utilised for a better purpose as indicated below.

Undisturbed samples can be collected from different depths at the site and thus valuesof Cu can be estimated by this method of repeated triaxial test at different depths at the same site. Thus the trend of variation of Cu with depth can be ascertained by this method very easily. Since model block vibration test at different depths at the same site is very costly and time consuming, it is felt that a single model block test may be performed at suitable depth and coefficient of uniform elastic compression may be determined at that depth. The value of Cu from this test may be modified in view of obtained variation from cyclic triaxial test. Suitable depth of foundation for the machine foundation and the corresponding value of Cu may thus be chosen.

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"Some books are to be tasted, others to be swallowed and some few to be chewed and digested"

—Bacon

"INTERNATIONAL WATER SUPPLY AND SANITATION DECADE" AND OUR COUNTRY.

By **A. K. Datta**
Asst- Prof. of Civil Engineering Dept.
B. E. College, Howrah.

The water enviroment in our country need much more respect than what it is getting now. Inadequate supply of water, or even no provision of safe water, poor sanitation and consequent pollution of water courses, water borne deseases etc. are the part of life in our country, and are the gross symptoms of the state of our under development.

It is well established that no other single factor, than the provision of access to the safe water, can improve the well beings of the people. Several water borne deseases like Typhoid and Paratyphoid fever, Cholera, Bacillary Desentery, Amebic Desentry, Infectious Hepatitis, and other gastrointestinal upsets and some worm infectious are caused solely due to poor water quality management (which include inadequate treatment of water, careless discharge of domestic and other wastes into the water courses etc). It is estimated that a better sanitatton will protect about 4/5th of the world's population from a wide range of deseases.

In India, only about 40% of the urban population are provided with piped water supply. Many of them however are unable to maintain the required water quality standard. In some places, fault lies with the distribution system, where leakage in the pipes causes extraneous pollution, in some other places inadequate water treatment facilities are responsible for the poor quality of water. In one survey, it was observed that, the water supply in many railway stations in our country is unfit for human consumption. In villages of our country, the picture is far more bleak ; only 10% of the rural population is supposed to get the piped water supply at the end of the 5th Five year plan period. There are villages where there are no means even to get 10-15 litres of drinking water per head per day.

In regard to the sanitation, most of the towns are not having any scientific waste collection system. Only about 227 towns in our country are partly sewered, and about 186 towns have some sort of sewage treatment facilities. Let not speak about the villages where about 96% of the houses are not having a latrin at all. The poor sanitation is responsible for higher rate of death due to water borne deseases in our own country, which is estimated to be 360 out of 10,000. It is very unfortunate that even after thirty three years of independence, Pollution Control and Environmental Sanitation are given a low priority in our country.

Now, one may wonder, why we were unable to provide the above basic facilities to our people—where lies the fault ! So far as Technology is concerned, India has got no dearth of technology for water supply and pollution control. In fact, the problem is entirely socio-economic in nature. The developing countries like India has to overcome a big financial barrier to implement all the above type of beneficial schemes. At the same time the problem demands its proper evaluation and a whole hearted effort for its solution in a befitting manner.

The cost involved in the implementation of conventional water supply and waste collection system is very high, and is often beyond the economic reach of the communities in many areas of our country. It will be sufficient to mention that, on a very rough estimate, the capital cost of installation of water supply system including treatment, distribution and house connection is found to be Rs 115/- per head ; while that for a sewerage system, including house connection and treatement is around Rs 425/- per head (these are old data —current figures will be definitely higher). As such to provide adequate water supply and sanitation facilities, we have to bring down the cost of implementation drastically ; and to do so we have to think for some low cost alternatives. With full regards to the western or modern technology and also keeping in mind the ultimate "targets", we must opt for some intermediate or appropriate technology for the immediate and interim solutions to both water supply and waste disposal problems. Low cost appropriate technologies are developed by the Indian scientists and engineers. It requires only a bit of respect to those indegeous. technologies and a courage to implement the same.

So far as water supply is concerned, piped water supply, from a properly managed water works, can only ensure a safe supply of drinking water to the communities. But from the progress so far made by our country in regard to the implementation of water supply programmes, it is apparent that, for many years to come, we have to depend on existing sources of water, such on ponds, dug wells, spot tube wells, rivers etc. But the set quality standards of the drinking water, particularly the bacteriological standards, should not be sacrificed, under any situation. What the existing sources require immediately is the proper attention for their protection, and at the same time arrangement for the disposal of wastes of the community without causing any danger to the sources. Several techniques have been developed in our country for disinfection of water in the wells, viz, one pot or two pot method of chlorination of dug wells, fixed bed chlorinators for the tube wells etc.

So far as sanitation is concerned the problem area may be divided into three sectors : (1) Industrial water pollution control, (2) sanitation in the urban areas, and (3) rural sanitation.

As per water (Prevention and Control of Pollution) Act 1974, all the Industries are bound to render their liquid waste harmless prior to their discharge into the water courses. So only a strict vigillance, sense of responsibilites and time can resolve this problem.

Very few municipalities are having sewerage and sewage treatment facilities. But the modern technology or high level technology utilised for the design and construction of above facilities, is not generating a result upto our earlier expectation. Very few sewage treatment plant are functioning properly. Low cost technology is the most appropriate technology in our country in this sector. The low cost treatment units like Oxidation ponds, Anaerobic Lagoons, Aerated lagoons, etc may be adopted for the treatment of community waste water, in preference to Activated Sludge Plants or Trickling Filters.

It is obligatory to have a Sanitary privy with septic tank in a newly constructed house in the urban and semi-urban areas. Modified indegenous low cost design of septic tanks are also available. But the service privies out number the sanitary privies in all the areas, and they are still a big headache of the civic authorities. Though programmes are being undertaken for the conversion of service privies to sanitary privies in some areas of our country, the majority of the communities will have to depend on service privies for many more years, if not decades, to come. As such, the present method of collection and disposal of night soils needs immediate reevaluation and a technically sound and cheap alternative should be recommended for adoption. If sewerage is considered to be the target, instead of spending a lot on conversion of service privies into sanitary privies, as an interim measure, we may construct "night soil treatment plants" where the collected night soils (of course through a more scientific method) would be rendered harmless. The above plant may be converted into sewage treatment plant, after the construction of sewerage system and conversion of service privies into sanitary privies and subsequent house connections, in stages.

In rural area, the problem is altogether of different nature. Here also the major problem is of excreta disposal. The flush out type bore hole latrines are usually recommended for sanitary disposal of human excrements in the cheapest way. But it is very difficult to throw any technologically sound solution on the rural folk, many of whom never cosider the latrin a basic comfort at all. Mass education on environmental sanitation is the immediate necessity ; unless they accept the thing only financial supports will not yield any substantial result.

In UN water conference held at MAR-DEL PLATA, Argentina on 14-25 March, 1977, it was decided to designate the period 1981-90 as the "International Water Supply and Sanitation Decade", and have taken a pledge of providing drinking water @ 20-30 litres per head and associated sanitation to every individual by 1990. It is an uphill task. The cost involved is beyond socio-economic reach of our country. With new innovations in the field of low cost technology, proper planning and appropriate allocation of fund, and mass education, let us hope to achieve the goal within two or three decades to come, if not in 1990.

"All art is but imitation of nature

—Seneca.

MECHANICS OF STRUCTURES—ITS ORIGIN & GROWTH

By

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The Science of mechanics of structures was developed to determine the dimensions of different members of construction on the basis of their strength. The Romans earned reputation as veteran builders and rules for methods of building can be known from the book of Virtruvius, a famous Roman architect and engineer. During the period of Renaissance, science and engineering attracted the notice of the elite anh Leonardo da Vinci (1452-1519), an eminent artist took interest in this field. He not only put forth the idea of the tensile strength of iron wires but investigated the strength of columns and stated that the strength varies inversely as their lengths and directly as some ratio of cross sections. Let us try to go back to the sixteenth century and trace the path of development of the subject of mechanics of structures.

Galileo (1564-1642) of Pisa in his book "Two New Sciences" included all his works on mechanics of materials. He studied the tensile strength and the bending of beams including the beams on two supports with the finding that the bending moment is the greatest under the load and is proportional to the product of the lengths on either side of the beam. Mariotte (1620-1684) was famous for introducing the importance of experimental techniques into French science. In mechanics of solids, he introduced the laws of impact and developed a theory of bending considering the elastic properties of the material. He also investigated the problems of bursting of pipes under internal hydraulic pressure. Robert Hooke (1635-1703), son of a Paris Minister, was connected with the Royal Society. Apart from studying the deflection of beams, he considered the deformation of longitudinal fibres of a beam in bending and stated that the convex fibres will be under tension while the fibres on the concave side will be compressed. It is well known that the linear relationship between stress and strain was propounded by him which marks the foundation of the science of mechanics. John Bernoulli (1667-1748) of Basle, the greatest mathematician of his time formulated the principle of virtual work in his letter to Varignon. Daniell Bernoulli (1700-1782) best known for "Hydrodynamica" worked on elastic curves and wrote to Euler "since no one is so completely a master of isoperimetric method (Variational Calculus) as you are, you will easily solve the following problem in which it is required that $\sum$ ds/r² shall be a minimum". As we all know that the integral represents the strain energy of a bent bar neglecting a constant factor. He also derived the differential equation for the lateral vibration of a prismatic bar for the first time. Leonard Euler (1707-1783) while at Berlin wrote his "Introduction to Calculus" (1748), "Differential Calculus" (1755) and "Integral Calculus" (1768-1770) which inspired the mathematicians of his time and led to further works toward the end of eighteenth century. He investigated and classified the shape of elastic curves of beams under various loads with the help of variational calculus. He also studied bars with variation in cross sections and bending of bars with initial curvature. He showed that the differential equation of the elastic curve for a beam with distributed load will be of fourth order. In 1757 Euler published his findings on the buckling of long columns including columns of variable cross-sections and columns with distributed load across the length but unfortunately failed to arrive at the correct solution. J. L. Lagrange (1736-1813) introduced the concept of "generalized Co-ordinates" and "generalized forces" and tried to attribute a general concept to the theory of mechanics. His important works is towards finding the elastic curves of long columns under load in his memoir "Sur la figure des colonnes" and showed that a column may have an infinite number of buckling curves. He also made valuable contribution in discussing the problems of columns of variable cross sections and bending of uniform cantilever strip.

Scientific investigations in the eighteenth century are mainly carried out by persons attached with academy of sciences where the pursue of knowledge was the main motive force ; but in the next century, applications of the laws were carried out in various fields of engineering. In 1798, the first book on Strength of Materials was published by Girard in which the strength of beams and the buckling of columns was the principle topic of discussion. C. A. Coulomb (1736-1806) contributed the most in his century towards the development of the science of mechanics. In 1784 he produced his memoir on finding the torsional rigidity of wires and extended his investigations on the mechanical properties of materials. He also discussed the damping of torsional oscillations.

Science of mechanics gradually found wider application in engineering constructions and theory of retaining wall and arches were worked out together with the stability problems in the eighteenth century. To discuss the important contribution mention may be made of Navier (1785-1836). During his period, the chief material of construction was shifted from stone to various metals and the construction of bridges was most important. In many of these constructions, cast iron was used which worked mainly in compression in arch bridges but a number of such constructions failed. Navier was sent to England by the French Government to study the art of building suspension bridges. However, in 1820 Navier published a memoir on the bending of plates and in 1821 he presented the fundamental equations on the mathematical theory of elasticity. In 1826, his book on Strength of Materials was printed. He showed how to calculate the ultimate load and determined experimentally the value of the modulus of elasticity, E. He also discussed the bending of prismatic bars with the load applied in the plane of bending. He is the first to show that the analysis of an indeterminate problem is possible by deriving sufficient number of equations from the consideration of the deformation of members. He also determines the elastic curves of beams by integration. Despite various important contribution, he could not find correctly the locations of the maximum shear force and bending moment in beams which are considered as the basis of design now-a-days. Besides the above, he developed a theory for analysing curved bars in bending and discussed problems of retaining walls, arches, plates and trusses.

During the years 1800 and 1833, important contributions have been made by the French engineers in the field of experimental techniques of testing materials. Experiments on bending of beams, tensile test and deflection etc. were performed and the effect of dimensions on these were extensively studied. It may not be out of place to mention here that during this period attention of scientists were drawn towards the application of theories in practical engineering problems specially in designing of suspension bridges.

Thomas Young (1773-1829) made valuable contribution in deriving conclusions in connection with tension of bars, torsion of shafts and lateral buckling of long columns. He also contributed much in the subject of strength of Materials by introducing the concept of modulus in tension and compression and showing the method of analyzing impact stresses in elastic materials. In his work entitled "Natural Philosophy", he included important original solutions of many problems of strength of materials. He was not only a pioneer in studying natural science but also in tackling problems of engineering interest. He treated the hull of a ship as a beam and calculated shear force and bending moment at several sections assuming a definite distribution of weight.

The above theories and developments were made on the assumption that in beams plane cross sections remain plane after deformation and the material follows Hooke's law. The idea, however, existed from the time of Newton that the elastic characteristics of a body can be explained and analyzed by the assumption of a force of attraction and repulsion between particles of the body. The idea was further put forward by BOSCOVICH and this was taken up by Poisson in the investigation of the bending of plates. This is how the concept of the theory of elasticity was gradually introduced. Augustin Cauchy (1789-1857) introduced the idea of stress and showed three components of it on an inclined plane of an elemental tetrahedron. He also derived the differential equation of equilibrium of an elemental rectangular parallelopiped in terms of stress components and also worked out the strain components at a point in terms of displacement components. Poisson and Navier obtained the differential equation of a laterally loaded plate independently and Navier also explained the method of solution of a simply supported plate inthe form of a double trigonometric series.

Barre de Saint Venant (1797–1886) cotributed a great deal in the field of theory of elasticity. He was not only interested in analysing a body subjected to statical load but also studied the dynamical action of a moving load on a beam and also the effect of impact load on it. He published several important papers in this respect. He took great interest in deciding actual number of elastic constants in solving the equation of elasticity. In 1853, Saint Venant published his famous paper on torsion including his semi-inverse principle. As regard the important contribution, next mention may be made of G. R. Kirchoff (1824-1887) and A Clebsch (1833-1872). The former's important work is in connection with the theory of bending of plates with two well known hypothesis. He also derived the expression for potential energy of a bent plate and thus derived the famous plate equation from the energy principle. His another important contribution is in finding the general equations of equilibrium for three dimensional deflection curve of a bar when the deflections are not small. The later was mainly a pure mathematician and put forth new mathematical tools for solving elasticity problems.

J. V. Boussinesq (1842-1929) applied the concept of potential functions already used by Lame and Kelvin in variety of problems concerning the stresses and deformations produced in a semi–infinite body by forces applied on the boundary. A .E. H. Love (1863-1940) is a well known worker in the theory of elasticity. He started his work in the theory of thin shells. He also studied vibration problems and analysed the problem of elastic equilibrium of a solid sphere. He contributed substantially to the investigation of the propagation of seismic waves and suggested a correction to the work of Rayleigh which now bears his name. H. R. Heitz (1857-1894) is also known as a good worker in the field of elasticity. He worked on the compression of elastic bodies and studied the hardness of materials. He discussed the problem of stress distiibution in a long cylinder subjected to a load perpendicular to its axis and also in circular rollers such as are used in bridge bearings.

In the early part of the twentieth century increasing importance was put in the equations of the theories of elasticity which quickly called for various approximate methods of solutions for want of exact methods of analysing them. In 1908, C. Runge utilised the method of finite difference in solving Poisson's equation in tor–sion problems. Thereafter there extensive use was suggested by L. F. Richardson in 1910 and by R. V. Southwell in 1940. Rayleigh-Ritz method has proved to be very. effective for getting approximate solutions of elasticity problems. Minimum energy principle has also been utilised for many problems with great success. The Ritz method has also been used in conjunction with the principle of least work.

Wide use of steel and high strength alloys in various structures and machine components has made the problem of elastic instability a problem of great importance. Important contributions made in this respect are by Goodier, Wagner, Vlasov, R. von Mises and others. For quite a number of years Finite Element Method has almost replaced any other numerical method due its high potentiality and advantages in application in various fields.

In the above discussions, the developments in various experimental techniques used now-a-days such as photoelasticity etc. have not been discussed and only a cursory glance has been made in depicting the developments in the subject. We must look forward for more sophisticated mathematical tools and refind numerical methods for the solution of elasticity problems in view of their increasing applications in various fields of technology.

"Life is a flower of which love is honey"
—Victortugo.

URBAN TRANSPORTATION AND PUBLIC POLICY

By

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C. M. D. A.

1. Transportation & Urban Growth.

Transportation has always played a vital role in the growth of cities and urban areas. Urban centres through ages have developed along the public transport corridors, water-ways, road-ways or railways. The city size and form have depended to a significant extent on the transportation mode available at the time. In early 19th Century, the city was confined within about 2 miles from the core, the distance that people could walk along. With horse-drawn cart, the city boundaries expanded several more miles. With electric street car the city boundaries expanded further. And the real urban explosion started with the advent of automobile.

Transportation corridors from the basic structure of the city. The city over time changes its character. The activities change, the land use changes, even the transport modes undergo substantial change, but the corridors continue to remain and continue to provide the basic flow of activities. In shapping the land use and activity pattern of the city the transport structure has a very dominent role.

Transportation has a particular significance in the growth of metropolitan areas. The large cities, in early period, developed in coastal locations because of transportation facilities across the sea. Penetration to the hinterland provided difficulties. With the advent of railways the metropolitan influence expanded to the region. But this provided an axial range of influence along the railway corridor. The automobile transportation defused the metropolitan influence to remote places free from the confine of water front or railway tracks and the world witnessed the growth of large metropolitan areas in various parts.

Transportation thus is a key and critical input that defines and dictates the intra-urban and inter-urban development pattern. Through planned development of the transportation system it is possible to achieve balanced urban, metropolitan and regional development through better linkages. Government policy of guiding and structuring the growth and achieving dispersal objectives can also be ensured through planned transportation system. Both as a supportive infrastructure and as a promotive catalyst to development, transportation has a very important role in physical, social and economic life of the nation in generaral and urban areas in particular.

2. Urban Transport Problems & Constraints.

During the last four decades automobile has become the dominant mode of urban transportation because it provides the unique advantage of combining flexibility with mobility. The growth of automobile has promoted dramatic urban expansion and has contributed significantly to the economic development of urban areas and the region. But at the same time this has brought with it a number of associated problems.

Most commonly realised problem is the traffic congestion. It is a paradox that while the potential speed of automobile has gradually increased with the improvement of automobile technology, the actual operating speed in urban areas has been decreasing day by day. The peak hour travel speed on busy corridors in major cities of world is in the order of 10 to 15 miles per hour. In Indian cities it is still lower. There is a colossal wastage of man-hour due to traffic jam in our cities. This has adverse economic effects as well.

Lack of parking place and terminal facilities is another problem in urban transportation. Unlike other forms of transportation (viz. railway, air or water transportation) road transportation has grown without adequate attention to the need for parking and terminal facilities. As a result the roads have been converted into parking areas and mobility has been sacrificed. The parking situation is particularly critical in the central areas and increasingly we are facing a situation where one is forced to park car at quite a distant place and reach the destination by some other mode or on foot. The flexibility is thus being lost gradually.

Accident is considered to be one of the evil associated with the road transport. Death due to road accident is increasing every year and loss due to injury and property damage is also mounting high.

Lack of pedestrian facilities is another important problem created by unplanned expansion of automobile transportation in the urban areas. About 80% of total death due to road accident in large cities in India occur to the pedestrians.

The rapid growth of automobile transport has also resulted in environmental hazard and pollution in urban areas. The noise level has increased much above the desirable limit. The emission of carbon monoxide is creating environmental pollution. There is gradual steady encroachment into the open spaces and parks to make room for increased need for transportation. The architectural and historical sites are being destroyed. The garaging, servicing and maintenance of car in residential areas affect environment. The entrance of trucks and other commercial vehicles has adversely affected the quality of urban life and has become a serious threat to children. The clutter of signs, signals and railing, the dull drab form of car parking areas and highway moving through cities dislocating residential areas are all contributing to gradual degradation of the urban quality.

The rapid increase of motor vehicles in urban transportation scene with all its associated problems as indicated above has caused serious concern in almost all large cities of the world. Initially efforts to bring solution in western cities, particularly in the United States, consisted of massive expansion programme of transportation facilities specifically the road and highway street system. This phase continued till mid-Fifty when it was gradually realised that expansion of highway facilities in the urban areas, oriented towards private automobile movement, in effect, bring more problem than it can solve. In Los Angles, for instance, it was seen that 2/3 of the CBD land was utilised for providing highway and fly-over facilities with costly interchange system. This raises serious doubts about the economic usefulness of such programmes. Gradually the shift was towards more utilisation of the urban transit system and effecting maximum utilisation of the existing street space. During the last ten years the nature of urban transport development programme has undergone substantial change in outlook and philosophy even in affluent western cities. In India, like many other developing countries, the usual problem of transportation in large cities has been very severely intensified because of extreme lack of resources. In a situation where only 20% of the total population lives in cities and where about 3/4 of the people live below the poverty line, making large investment in the field of urban transportation after meeting the competiting demand of other sectors is neither feasible nor desirable. On the other hand, in terms of absolute number, the large cities are continuing their growth and the travel demand is also increasing. As a result the gap between the demand and supply is becoming wider day by day. Quite clearly, new approaches for meeting urban transport problems are called for. The strategy for development in urban transportation field should therefore be formulated within a well defined public policy frame that would recognise the current realities of the socio-economic scene and the technological options available.

3. Strategy for Development and Public Policy.

The current situation of urban transport in large cities in India particularly in Calcutta is alarming. If the existing trends are allowed to continue unchecked, the prospects are even more disquieting. Possibilities however, do exist for combatting the threatened deterioration in urban transport if strong action is taken after making a careful and realistic reconsideration of policies affecting the urban transport. Three main directions for attention are evident. These are :

— Rationalizing transport and road space use.
— Providing priority and promoting efficiency and co–ordination in public transport.
— Relating urban transport to urban form.

In each of these fields practical opportunities for effective action do exist. If, however, requires implementation of a carefully formulated action programme within well defined policy frame.

Rationalization of Transport and Road Space Use.

Transportation facilities particularly the roads and highways system are long life but high cost facilities. The performance of these facilities depends to a very considerable extent on the efficiency of operational control and management system. A practical approach to promoting efficient use of transport facilities is by traffic engineering to reduce the obstruction that different flows of traffic cause to each other, particularly at intersections. Effective road capacity can in some cases be increased by about 50% by installation of co–ordinated signal control, intersection redesign, introduction of one way circulation, introducing efficient street signs, road marking and other suitable control devices and some such measures. The traffic engineering programme, however, should be closely linked with improvement of urban transit facilities. The objective should be to increase the road capacity in terms of passenger per hour rather than vehicles per hour. This could be achieved by providing priority for bus operation through bus-ways, bus lane, bus priority at intersection and such other measures.

Implementation of intelligent traffic engineering programmes would increase the capacity of existing road and street system to a considerable extent. But the benefits of such programmes would be nullified in no time if private automobile travel is allowed to grow unchecked in busy areas of the city. The present trend indicates that motorisation is faster than urbanisation and private car growth is faster than motorisation. The growth of number of people capable of car owning is higher than growth of per capita income. The growth of private automobile travel is the main contributing cause to the creation of traffic congestion. And congestion hits public transport more than private auto. The cost of relieving congestion increases with degree of congestion. The situation is particularly critical in central area and other key locations and corridors. In such locations road space is a scarce and very costly resource. Any misuse of such resource will have adverse economic and social effects. In the current situation the cost of moving private auto in central and other key areas is more than the users pay for. This means that private auto travel is being subsidised, though indirectly. The user of the facility belong to higher ten percent income group and any subsidy to there is socialy and economically regressive. Looking from physical angle also private auto travel is more inefficient than public transport. With current occupancy ratios and passenger equivalency values, bus is about twenty times more effective than a private car in terms of passenger carrying capability. In Indian cities about 70 to 90 per cent of passenger trips are performed through public transport system. All these considerations clearly suggests that restraint to private automobile movement should be introduced in appropriate measure as a policy in central and key areas and corridors. This may be effected through some appropriate pricing mechanism, parking charges, area licensing, physical restraints, etc. But this has to be done. The programme for urban transport improvement should be formulated to secure such restraint.

Another major element that has great bearing on traffic congestion and road space utilisation is the operation of truck. Movement of trucks, loading-unloading their servicing, repair and fueling—all have adverse effects on functioning of city system and deteriorates the quality of urban life. At the same time the city can not live without the truck. Quite clearly, the approach should be to formulate measure of restraining the truck operation in such a way that the adverse effects are minimised without affecting the business and commercial activity and economic productivity. Regulatory and control measures should be duly matched by facilities like properly planned truck terminals at appropriate locations together with warehousing and other facilities necessary for truck operators and wholesale traders.

In our cities major attention has to be given to the pedestrian and slow traffic. Traffic management and urban system planning should recognise the importance of pedestrian and slow traffic in our cities. Domination of motor transport as reflected in indiscriminate curtailment of footpath needs to be curbed. Due provision should be made for the pedestrians in signal timing for safe crossing. Closing some central area streets to vehicular traffic at peak periods merit serious consideration.

New road construction should only be considered when the measures to increase the capacity of existing facilities as indicated in above paragraphs are insufficient, when specific links in the road network are missing, special facilities to improve existing acute bottleneck location are required or when justified for economic productivity in the total development strategy.

PUBLIC TRANSPORT PRIORITY : PROMOTING EFFICIENCY & CO-ORDINATION.

About three forth of the total passenger trips in Indian cities are usually made by public transport facilities. In Calcutta, this is as high as 90%. The transit passenger volume has grown progressively over the years. But the supply of transit facilities did not match with the growing demand. The resulting situation is that urban transit is now a very serious problem in almost all cities in India. We have to-day inadequate supply of transit vehicles resulting long headways, producing long waiting at bus stop and extreme crowding in the buses. The terminal facilities are mostly inadequate. Loading and unloading of passenger are uncomfortable and unsafe. Travel has become very difficult and frustrating. Due to many factors the public sector transit operators could not extend the system. This has resulted in inadequate route coverage, long and costly feeder trips, long walking and long waiting. Due to very low fare structure the revenue is inadequate to meet even the operating cost. This has resulted in inadequate maintenance and repair arrangement for the public sector operators. The productivity has been reduced. The system of management has been inefficient and all these have resulted in further financial difficulties. The inter-model coordination is also lacking. Transport facilities have become more and more costly and the gap between the demand and supply is, therefore gradually becoming wider and wider.

Urban transit in large cities has been mostly nationalised. The quality of transit service in future will depend largely on the ability of the operators to increase efficiency and productivity. As a policy public transport is to be given urgent attention with highest priority. The measures to improve efficiency and productivity shall include reducing bus staff ratio (say to about 10), improving fleet utilization (say to about 85%) increasing vehicles utilization (say to about 20k.m. per bus per day) making adequate arrangement for maintenance and repair in improved depots and workshop and on top of all improved management system for increased staff productivity through better training and incentive scheme.

Transit fare has been regarded traditionally as a sensitive issue. With rising cost of fuel, spare parts, wage bill and everything else, it is difficult to meet the operating costs, without some enhancement of fare. But increase in fare should be related to increase in quality of service.

Transit operation efficiency depends to a large extent on the route structure. There is considerable scope for rationalizing the route structure. This is particularly necessary in a city like Calcutta where the transit system include multiple models. There should be reorganisation of the route structure with the due consideratiion of passenger demand, route economics, road network, terminal locations, depot location, model characteristics and other relevant factors. This would call for integrated efforts to develop balanced transit system plan where the different modes would be complementary to each other without being competitive.

Transit demand during peak hour may be reduced by adopting such policy measures as staggering office hours, balancing tidal flow through land use planning and pricing machanism. These should be attempted to secure maximum relief to peak hour transit load.

URBAN TRANSPORT & URBAN FORM.

Policies and investment programmes in urban transportation field are often implicity based on questionable assumption that existing traffic flow pattern is rational that single concentrated central business district is efficient, viable and inevitable and that possibility of locating alternative centres of activity do not exist. There is no simple solution to the question of what is best urban form. City size, function, income level, resource availability and necessary other factors need to be considered for finding such answer in respect of a particular city. But analysis of various factors strongly suggests that it would be feasible to adopt with advantage alternative urban structure, that economizes on costs of transport and other infrastructure but provides improved access and living conditions.

A primary consideration should be to locate the place of work and residences of the workers in reasonable proximity. In guiding the urban expansion this consideration should be given due importance as a matter of policy.

Easier movement of goods without abverse effects or other urban activity is another major consideration. Truck Terminals and Loading areas, and wholesale and retail markets are required at locations that are efficient in terms of accessibility and removal of central area congestion. Relocation of existing markets centrally located for historic reasons and with inadequate capacity may be inescapable in certain cases. The policy should be to locate additional business and Government offices, educational and other institutions, in new centres avoiding accentuation of peak-hour traffic congestion in existing CBD.

For large metropolitan city multinuclear urban from promoting new centres of activity near existing urban periphery have many advantages. Promotion of new activity centres with adequate accessibility and facilities to attract at least a part of activities of the existing CBD, however, would require a high minimum level of investment. A very slow incremental approach will often fail to attract enough business sufficiently quickly for the mutually supporting activities to develop satisfactorily Quite clearly, not more than one or two additional activity centres can generally be promoted at a time. It is also unlikely that individual basinesses can roadily break away from central area, despite the increasing rents, without dominant support of appropriate land use and transport policies. To remedy this situation and to utilize the private investment to greater advantage, action at several levels is required. It is necessary to relate land use regulation and urbun transport development to the desired urban patterns ; to ensure timely minimum levels of investment in selected activity centres and to adjust the taxes and charges more realistically.

Transport has always a strong influences on location. Particularly when land use control is weak, the role of transport policy and investment in guiding the urban form becomes considerably more important. The effectiveness may be greatly increased by appropriate pricing mechanism. It would be unfortunate if these tools are not used to the full advantage to combat the threatening current conditions.

Realisation of appropriate urban transport and urban pattern is seriously affected by the lack of understanding and consideration of alternative transport strategies due to conventional planing approach. Urban transportation planing methodology developed in affluent western cities involving sophisticated mathematical modelling and computer technology has little relevance to the cities of developing countries because the uncertainty of the change in the economic and social structure as well as land use and physical conditions severely restricts the applicability of any predictive methodology The times and cost involved in such sophisticated planning methodology are also major constraints. Quite clearly somewhat different planning approach should be developed in such case. An effective alternative methodology may be to use a "broad-brush" approach to formulate a general strategy plan outlining the possible alternative long term perspective plans. Within the overall perspective short-term action plans may be developed. Alternatives may be tested and evaluated on the basis economic return and action plans to be related to the investment programme. The strategic plan should provide a flexible frame, adoptable to respond to the likely changes in basic planning parameters. Thus the transport development plan should be a short-term action programme to improve the immediate current deficiencies and at the same time would form part of a long term transport strategy plan for achieving a more desirable over all urban structure with more efficient, more economic transportation system to ensure improved mobility and accessibility as well as better urban life. This requires the planning, programming and policy making functions to be fully related and closely coordinated activity in respect of total urban system including transport. The earlier we achieve this better are the chances of survival.

[Presented in a seminar of Bengal National Chamber of Commerce & Industry.]

"Personality is to man what perfume is to flower".

—Charles M. Scheweb.

SUB-SOIL CONDITIONS OF CALCUTTA REVEALED FOR RAPID TRANSIT STRUCTURE

by Ajoy Mukhopadhayay (5th year)

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A knowledge of the geo-technical conditions of the subsoil is necessary to find out a sure, safe and economic solution to the construction problems of the Rapid Transit Structure.

To be more specific, a careful study of the subsoil conditions is necessary for ascertaining (1) whether for the chosen alignment for the subsoil conditions are satisfactory, (2) what construction methods would be adequate and satisfactory, (3) which are the sections to be done by each construction method, (4) what construction method would eliminate any possible damage to the neighbouring buildings, (5) whether any special treatment will be required for the sub-soil at any place and (6) whether any subsoil will cause any corrosion or detoriation of the structure in course of time.

For all these a systemetic study of the physical and chemical properties of the sub-soil is necessary. Calcutta lies on the gangetic alluvium plain whose depth in this region extends to several thousands metres. No bore hole has been able to pierce the alluvium to touch the rock below. The records of tube-well more than 300m deep have revealed upto the full depth of the existence of the numerous layers of peat, kankars and clay beds in association with the thick layers of sand. Some remains of fossils have also been found in the deposit below 250 metres depth. The various depth show the slow and the uneven surface of strata in which they are found. The most interesting of these beds are :

(1) a layer of peat about 1 metre thick at about the M. S. L. (2) a layer of dark grey clay more than 7 metres thick with remains of sundritrees and roots and (3) clay mixed with kankars.

For want of proper name the second strata is also called peat. From the various studies it has been concluded that the Calcutta peat is detrital in character and at least contains some drifted material which clearly accumulated in a large marsh or lake.

50 nos. of bore holes were sunk in Dum Dum--Tollygunge section. The bore hole records generally reveal the subsoil is soft in the upper horizon except for the top crust which is moderately stiff to firm. The consistency generally increases with depth and becomes

stiff to hard clay. Where sand has been encountered it is moderately dense in the upper horizon and becomes dense to very dense with increasing depth. Out of 50 bore-holes, about 33 bore holes reveal fairly systematic subsoil conditions with depth covering the major area of the route length. Specific physical characteristics of the sub soil strata would be necessary to correctly visualise the behaviour of subsoil during various phases of construction. It appears that the following further investigations will be necessary.

(i) Doing bore holes along with route alignment of 100 m. intervals or even closer in between the stations and at 10 to 50 m. interval at stations. The bore holes should be taken at least 10 m. below the bottom level of construction (ii) Determination of the actual physical conditions of stratum II, when subjected to long exposures in an open excavation (iii) Detailed permeability characteristic of Stratum IV in relation to dewatering requirements during construction (iv) Detailed permeability conditions of the river channel deposits in relation to the dewatering problems likely to be encountered during construction. For this **Cluster Pumping Test** may be necessary, (v) Establishing the variation of standing water levels for stratum IV by long term observation on Peizometers. (vi) whenever the sub-soil profile indicates some abrupt change or deviation from the normal character of the profile or whether a particular stratum normally expected is found to be non-existent, a closer spacing of bore holes and for other methods of probing will be required for ascertaining the correct sub-soil picture.

Normal Calcutta Deposit :

The sub soil stratification of normal Calcutta deposit as revealed from the investigations are shown below.

		Top of Stratum (approx.)	
		Highest	Lowest
Stratum i	Light brown or brownish grey silty clay, clayey silt and sandy silt	Ground Level	Generally at ±00·0
Stratum ii	Grey or dark grey silty clay with semi-decomposed timber pieces	+0·25 —	−1·5
Stratum iii	Bluish grey silty clay and mottled brown or grey, silty clay with kankars.	−8·0	−17 5 (average −10·0)
Stratum iv	Brown, or yellowish brown sandy silt, silty fine sand with occasional tenses or pockets or brown and grey silty clay	−13·0	−22·0
Stratum v	Mottled brown or grey clay, grey and brown silty clay often with laminar character, all with rusty brown pockets of brown silt	−15·0	−27·0
Stratum vi	Brown or light brown silty fine to medium sand	−30.0	−45 0

Properties of the normal Calcutta Sub-Soil are tabulated as follows :

Stratum	Atterberg Limit		Natural Moisture Content	Cohesion C (Kg/cm²)	Angle of Friction (degrees)	'N' Values blow per 300m	Average 'M_k' Values (Cm²/kg)
	L. L. %	P. L. %					
I	60	21	30	0·28	0°	3 to 16	0·015
II	80	25	55	0.28	0°	2 to 8 upto 5 4 to 10 upto 5 to 10	0·04
III	60	18	30	0·56	0°	10	0·015
IV	38 to 44	15 to 25	26 to 32	0·42	15° to 33°	20 to 40	—
V	65 to 75	19 to 20	22 to 25	1·05	20° upto 35 30° below 35	—	0·005
VI	35 to 50	20 to 25	29 to 30	—	40°	50	—

Reference :—Report prepared under the guidance of Mr. G. N. Phadke, Chief Engineer (Construction) of Metro Railway, Calcutta.

"A smile is the shortest distance between two people."
—Victor Berge

ROAD PROJECT PLANNING WITH P. E. R. T.

by Ranjan Palit & Chinmoy Pal
5th year C. E.
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INTRODUCTION :

Programme Evaluation and Review Technique, commonly known as PERT, is a sophisticated and relatively new tool used by management for planning and control on special project. The special projects office of the US Navy concerned with performance trends in the execution of large military development programmes, introduced PERT on its Polares Weapon systems in 1958. Since that time PERT has spread rapidly throughout the US defence and space industry and as well as many other types of fields and industries.

One of the major assets of PERT is its comprehensiveness. It can be used by management from the inception of a project to its completion, aiding in the initial planning of a project, helping to establish it in terms of what the work should be, its construction schedule, its cost and finally helping management with the overall detailed planning and control of the project throughout its fabrication period. To overcome the manual labour involved in computation of various things, the PERT has been computerised. We see that PERT offers management many advantages such as offering a distinctly improved approach to planning, allows them to predict, evaluate and revised plans, provides a ready made standard against which performance can be measured, better management of resources available.

ROAD PROJECT :

It is needless to emphasize or mention that a project for the widening the existing single lane pavement to two lanes and strengthening of the pavement at the same time calls for a detailed PERT to execute its design and construction and it's completion within ten months for lessening traffic congestion in urban areas. This road project is planned through PERT because of the following reasons.

(i) It gives a better, accurate and more reliable basis to the planner than hit or miss method.

(ii) PERT chart instantly gives an overall picture of critical activities, progress made, time taken, progress required, time allotted and the like for the top management.

(iii) PERT planning is not stationary but but dynamic in nature as it can be updated as and when required.

(iv) PERT is such that it can be run on computer, and thus all the calculation done mechanically.

(v) No activity, however, small or insignificant can be left or ignored.

PREPARATION OF PERT NETWORK :

Assumptions made in preparation of network are :

1) No constraint on the resources of materials equipment and labour.

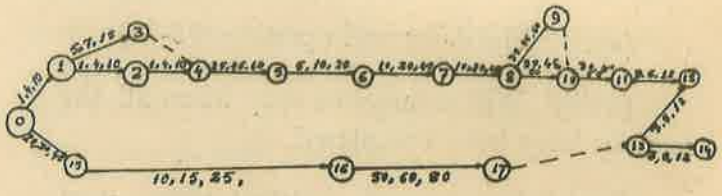
2) The work can commence in the month of April. There is a slack period of about $1\frac{1}{2}$ months (July and August) when due to monsoon the only activity that can be carried on is the water bound macadam.

3) The work is to be completed before the next monsoon starts.

4) Land has been acquired and alignment finalised and traced.

5) The work is split up into 4 smaller convenient subsections.

Each section will have the following works and for section (1) network is shown below.



TIME IN DAYS

FIG

(i) Clearing and grubbing (0-1)

(ii) Dismantling existing pavement (1-2)

(iii) Construction of temporary service roads for alignment (1-3)

(iv) Dismantling houses (2-4)

(v) Earthwork inclusive of carriage and compaction (4-5)

(vi) Gravel sub-base (5-6)

(vii) Water bound macadam Base Course (6-7)

(viii) Water bound macadam top Course (7-8)

(ix) Providing tack course (8-9)

(x) Providing levelling course of lean bituminous macadam (8-10)

(xi) Providing bituminous macadam (10-11)

(xii) Semi dense carpet (11-12)

(xiii) Construction of diversion of traffic (0-15)

(xiv) Dismantling existing culverts (15-16)

(xv) Construction of culverts (16-17)

(xiii), (xiv) and (xv) will be common to all four sections and therefore will not be affected by other works in the sections.

(xvi) Fixing Kilometre stones, Road Signs (12-13)

(xvii) Finishing and opening (13-14)

(xviii) Will commence only when all the sections have been completed.

From the network, critical path, start point, End point, Mean time, Variance, EST, LST, EFT, LFT, total float and free float can be calculated. From PERT we can see that the three time estimates takes into account the uncertainities and provides management with a degree of accuracy and honesty on which to base then decisions.

Reference :

(i) Journal of the Institution of Engineers (India) Students' Journal Vol. 14, Pt. Sl, July 1980.

"Our knowledge is the amassed thought and experience of innumerable minds." —Emerson.

GROUTING IN CONSTRUCTION ENGINEERING

By

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The majority of grouting operations carried out in construction engineering are concerned with anchor bolts, structural steel base plates and machinery base plates. The traditional grouting materials which have been in general use for many years are liquid grouts and fine con- crete of high strength.

Recent developments in chemical industry have made available CRI expanding grouts, and a number of synthetic resins having properties which make them potentially suitable for a variety of grouting applications.

1. CEMENT BASED GROUTS :

Cement based grouts can be used with a high content giving fluid mixture. The fluid grout consists of portland cement and a graded fine sand mix in a ratio not usually exceeding 1 : 2 by weight and it can be run into the grouting space as a liquid. The potentially high strength of this rich cement mix is offset by the high water content. Nevertheless, 28 days crusing strength of the order of 400 Kg/cm² can be expected. The high water content of these fluid grouts also results in a significant degree of shrinkage and thus cement grouts of this type may part from the upper surface of the grout during the initial setting period and subsequently drying out. These grouts have a low water permeability provided that cracking does not develop from shrinkage or from external mechanical causes.

2. EXPANDING GROUTS :

CR1 has developed know how for producing non-shrink mortar grouts. The latter incorporates an expansive component and makes use of ordinary Portland cement and well graded clean sand in certain fixed proportions. Grouts of this type are particularly suitable for those purposes where complete support of fabrication is essential to prevent under irable flexing under variable loads.

EPOXY RESIN BASED GROUTS :

The epoxies cover a wide range of synthetic resins of varying viscosity. A resin having a viscosity equivalent to that of a heavy lubricating oil can be used as an adhesive by activiting it with a suitable hardener. While mixing the resin with the hardener, a non-reversible exothermix reaction takes place during which the resin molecules become linked in all directions. During this reaction, the viscous fluid gets turned into a soft solid and eventually hardens, the whole process being completed within a few hours.

A wide range of hardener is available. In general, the more reactive the hardener, the greater is the temperature rise in the mix resulting in a lower initial viscosity, a shorter usuable life prior to setting, and earlier achievement of working strength.

Ambient temperature has a marked effect on both setting and curing times. These lengthen as the temperature falls. The epoxy resins most suitable for use in construction engineering will set and cure satisfactorily within the temperature range of 5°C to 30°C, the ultimate strength being unaffected.

4. POLYESTER RESIN BASED GROUTS :

Unsaturated polyester resins are manufactured as liquids which are almost as flnid as water. When activated by a catalyst they change from the liquid to the solid state without any significant release of heat. Unlike the epoxies, therefore, the rate of reaction has no effect on the curing time because there is no rise in temperature. Furthermore, since the physical transformation of the resin is initiated by the addition of a catalyst instead of a reactive component, the quantity of catalyst used is only of significance in relation to the speed at which the reaction takes place, and not to the properties of the end product. Thus reaction time can be controlled by regulating the proportion of catalyst employed. At a critical time during the reaction period, the water like resin rapidly sets and is fully transformed from a plastic to an elastic material within a few minutes. However, for grouting applications there will be limit to the viscosity which can be tolerated and also the filler grout must still be capable of completely wething the bedding surface in order to achieve maximum adhesion.

Physical Properties Of Various Grouting Materials

Basic in	Filler/ Binder Ratio By Wt.	Crushing Strength 7 days kg/cm²	Crushing Strength 28 days kg/cm²	Density kg/m³	Flexural Tensile Strength (at 7 days) kg/cm²	Direct Tensile Strength at 7 days kg/cm²	Modulus of Elasticity 10^4kg/cm²	Bond Shear Strength Kg/cm²	Linear Expansion /°C 10^{-6}	Linear Shrinkage %
Epoxy Resins A	2·2 : 1	82·7	96·5	1850	689	207	4·14	103	30	To small to measure
B	3 : 1	82·7	110	2080	48·2	—	10·03	89	18	,,
C	2 : 1	89·6	—	1980	48·2	204	2·07	—	26	,,
D	Unfilled	75·8	—	2080	40·0	159	2·07	—	30	,,
Polyester Resins E	1 : 1·75	—	—	551	—	92	—	1·79	20	0·3
F	Unfilled	965	—	—	2720	32	—	1·24	48	0·3 (dry)
Portland Cement Fine Cons.	1 : 1 : 2 by vol.	414	551	2400	41·4	20·7	20·7	41·4	—	0·05 at 12mm.
CRI Non-shrinkage Grout.	1 : 0·5 : 1·5 C : N.S. : S by. wt.	244	365	2400	—	—	—	—	—	0·10

"Shield Tunnelling"—An Outstanding construction work by M. T. P. (Railways) in Tube Rail Project, Calcutta.

by Subhasish Bhattacharyya.

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Introduction : Tunnelling is normally divided into two broad categories (a) tunnelling in rock, (b) tunnelling in clay.

The tradition was started here when a 2 metre dia tunnel was constructed under the river Hooghly for carrying of electric cables for the Calcutta Electric Supply Corporation. This cast iron lined tunnel was built under compressed air in 1931. The next tunnel, going to be now constructed, is the 5·1 metre internal dia cast iron lined tunnel for the Underground Railway in Calcutta. The total length of this tunnel would be about 2 KM. The tunnel will pass through typical Calcntta deposit and will make use of compressed air during working.

Investigation showed that subsoil of Calcutta can broadly be brought under two categories (1) normal Calcutta deposit, and (2) river channel deposit.

The tunnel for Calcutta Metro will fall in normal Calcutta deposit. This contains mainly clayey silt (containing semi decomposed wood and stiff Bluish grey silty clay with kankars. Along with the common Lab. test gas detection test was done and CH_4, CO. CO_2 and H_2S were found. The % of CO was rather high than what is specified in U. S. S. R.

Conditions of Methodology : The method of construction of a tunnel in soft ground like Calcutta should satisfy two conditions—first of all, it should be such as to accomplish the completion of the tunnel at the desired level with the least amount of subsidence on the surface ; Secondly, it should be such as to exclude the possibility of catastrophic accident during construc tion. In a tunnelling operation, the equilibrium of soil mass around the tunnel bore is completely disturbed. This is due to dragging and pushing during advancement of the shield and due to the fact that the excavated tunnel bore is larger in area compared to the final lining supports provided. There is, therefore, a tendency for the soil mass to close in around the lining rings. The sequeeze of clay into the tunnel can be substantially restrained by use of compressed air which decreases the stability ratio of the soil giving rise to increase in operational safety. During the operation, when compressed air is used, the water molecules are pressed back or rather retained in the pores.

Soil Cover : While tunnelling, a minimum soil cover is essential for the safety of the tunnel. Since the height of pressure arch is equal to the external diameter of the tunnel, the minimum cover between the crown of the tunnel and building foundalion should be at least 2B+D. Where B is the width of the largest building foundation within the influence region of the tunnelling works and D is the outside dia. of tunnel.

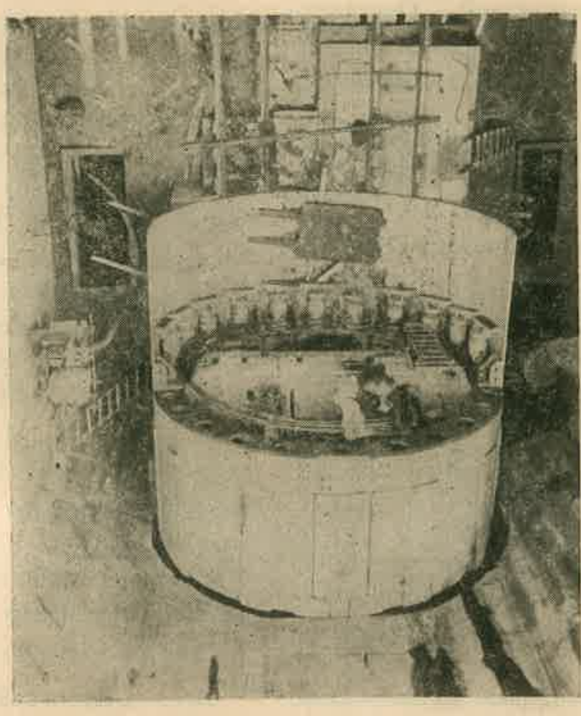
Lining segments for Shield Driven Tunnels : In the construction of tunnels by the shield method, it is essential for lining elements to have instantaneous bearing capacity, to be watertight and to allow for rapid and simple positioning or erection.

Cast iron lining : The permanent lining for larger diameter sheild driven tunnels is usually constructed of cast iron. Its main advantages are that it can be quickly erected and is at full strength to resist shield jacking pressures and external loads immidiately upon erection. Design for Calcutta Mètro :

For Calcutta Metro the material for the lining has been chosen as cast iron of grade 25 conforming IS-210. The lining has been designed for an average average overburden pressure of 15 metres of Geostatic earth. The flanges of the linear segment have been so designed as to take a jack thrust of 1900 tonnes (i. e. 19 jacks spread over the periphery with 100 tonnes capacity each).

Shield diameter and length : The diameter of the shield is dependent entirely on the outer dimension of the tunnel proper. The performance of the shield is mainly affected by its relative length, i. e. by relation of its length to its diameter (L/D). According to present trends it is kept in the region of 0·7 to 0·75.

The alignment of the tunnel of Calcutta Metro has been so chosen that the minimum cover under the canal is one diameter. This minimum cover is essentially required to avoid possible blow out.



(By courtesy of Metro Railway, Calcutta.)

Tunnelling for Calcutta Metro :

Method of working : Scheme for tunnelling in Calcutta Metro envisages an access shaft as well as destination shaft for use of tunnel shield. The access shaft will be the communication shaft for feeding materials into the tunnel as well as for taking out excavated spoils As such sufficient space near the access shaft to accommodate various ancillary units as well as space for handling of disposed muck and feeding materials.

The access shaft will also serve as a Shield Chamber for initial assembly of the shield.

After assembly of the shield a dome is erected at the top of the shaft so as to pressurise the shaft opening during the initial stages of shield working.

The shield will then advance by breaking the side wall of the shaft.

The shield will be pushed ahead by operating 3/5 jacks pressing them against the 3 metre long assembled ring.

After the rings of 3 segments have been erected for 7 metre length the erector is assembled on it. This seven metre of linings assembled in the shaft rest on sliding surface provided by means of embeded rails in concrete.

During initial advancements of the shield only 3 to 5 bottom jacks of 100 tonnes capacity are only in operation. Operation of more jacks than this at this stage causes vertical misalignment of tunnel.

Even during normal working of shield only 8 to 10 bottom jacks of 100 tonnes capacity are only in operation. All the 19 jacks with jacking force of 1900 tonnes are required only in exceptional cases, to take out the shield when it gets squeezed in the earth or at the time of re-starting the work after a long period of suspension.

The shield has a 'Nose-down' tendency due to its weight. This tendency will increase if top-most jacks are operated. Hense the top jacks are seldom operated. The force required during normal working is to counteract the skin friction and 10 to 12 jacks are more than sufficient to do it.

When the shield has to take a curve or when the alignment is to be corrected, tappered linings are used between the normal segments to achieve curve,

After the shield has advanced to about 60 metres, air—locks and pressure wall shall be erected. After erection of the pressure wall and air locks the dome at the top of the shaft shall be dismantled and, further working of the tunnelling will be carried on.

For the Calcutta tunnel concrete pressure wall is proposed to be adopted.

As the soil to be met with for Calcutta tunnel will be of very critical nature the whole of the tunnelling operation will be done with face board protection. In addition to the face board at its has been planned to provide peripheral lagging boards.

Another important feature of Calcutta tunnel is that the tunnel will cross a canal. As a safety precaution it has been planned to line the canal with 2 metre thick puddle clay for a length of 16 metres on either side of tunnel axis. This is necessary to ensure that during tunneliing there shall be no blow out and possibility of water gushing into the tunnel.

Because of paucity of space only 12 to 16 men work in the compressed air zone, and only 4 men work at the face. These four men do many types of jobs. They operate the face jacks as required, remove the muck adjust the face board etc. The same four men come down to work in the bottom half. Both bottom half and top half are not worked simultaneously. After the muck is removed the muck loader loads them in trolleys. These trollies are hauled by battery locomotives. The train or trollies hauled by battery locomotive crosses material locks and muck is lifted to shaft for disposal. Muck disposal is one of the very critical problems for achieving effective progress.

After the tunnel reaches the destination shaft wall shaft shall be broken and the shield emerges into the the destination shaft. The destination shaft for the Calcutta Metro tunnel will be a part of Shyambazar station. The shield is dismantled and taken out of this shaft. As such the destination shaft should provide adequate arrangement for easy dismantling of the shield.

Ref : Lecture delivered by Mr. **A. K. Sengupta** of M. T. P. (Rails)

Sewage Disposal System In Calcutta

by

Biswajit Chongdar : Final year ; C. E.

Paramanu Bhowmic : Final year ; C. E.

Not only during the rainy season but during the other seasons also, Calcutta will be flooded-now-a-days it stands to be a convention. Calcutta may be flooded by its own sewage due to its existing age old sewage disposal system, which is on the verge of collapse.

In a nutshell, the sewerage facilities of the city consists of the following :

a) Major Sewer network
b) Major pumping stations—at Palmer Bazar, Ballygunge and Dhapa Lock.
c) 5—Lift stations.
d) 7—Surface water pumping stations
e) Outfall facilities and and treatment at Bantola.

The sewer network system of Calcutta is generally divided into 3 parts—(i) Town System ; (ii) Suburban System and (iii) Maniktala System.

(i) Town System :

It covers the Northern Calcutta, sewege flow by gravity through branches and one main, to main pumping station at Palmer Bazar, combined sewage from the area between circular Road and circular canal also joins it. Sewage and storm water (together 3 × Dry Weather flow) is pumped into two high level sewers (8 ft. and 9 ft, dia.) upto 'Dry weather outlet'—originating at Topsia. Excess strom water is pumped directly into open town storm water channel which eventually joins Central lake channel, Suburban storm water channel and the Main storm water channel.

(ii) Suburban System :

Southern part of Calcutta comes under this system. Most of the sewage and strom water flow by gravity to Ballygunge pumping station. It consists of 3—trunk sewers and 2—lift stations at Chetla and Mominpur. Ballygunge pumping station pumps the sewage upto Topsia through 2—high level sewers (5 ft, & 8 ft dia.) Storm water is pumped directly into the suburban storm water channel which joins the Town outlet system at Bantala to form storm water channel.

(iii) Maniktala System :

Area east of circular canal is under its juridiction. Sewage flow by gravity upto Dhapa lock aud then pumped into Central lake channel for delivery at Bantala.

The outfall facilities may be subdivided into the following categories :

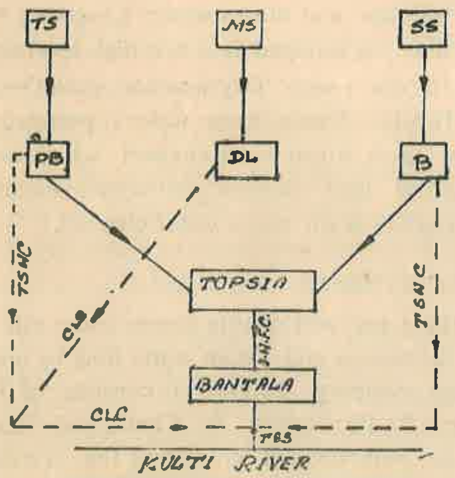
(i) Dry weather flow channel (D. W. F. C) :

It starts from Topsia and meets with central lake channel (C. L. C.) and suburban storm water channel (S. S. W. B) near Bantala.

(ii) Storm water channel.

The sewage of Calcutta Collected at Bantala is treated at Treatment Plant near Bantala. The treatment consists of primary sewage treatment (P. S. T.) and open pits are used for sludge digestion. The treated sewege flows about 6 miles and then joins storm water channel (S. W. C.). S. W. C. disposes off its flow at the river Kulti, which flows through the Eastern side of Calcutta.

For existing open drains in the Southern portion of Cossipore--Chitpore area and areas adjacent to Jessore Road "Bagjola Nikasi" serves as an outfall. Bagjola treatment plant near the Bagjola station treats the sew-age flow of 'Bagjola Nikasi'.



T. S.=Town System
M. S.=Maniktola System
S. S.=Suburban System
P. B.=Palmer Bazar
D. L.=Dhapa Lock
B=Ballygunge
D. W. F. C.=Dry Weather Flow Channel
T. O. S.=Town outfall System
T. S. W. C.=Town Storm Water Channel
C. L. C.=Central Lake Channel
SSWC=Suburban Storm Water Channel

In the corporation area out of 34 sq. miles only 20 sq. in. less is covered by sewer network (i. e. 54%). Sewer networks of Calcutta comprises of 100 miles brick sewer and 325 miles of pipe sewer. In the sewer-age system annual silt deposition is around 14 lakh c. f. .t After 1973 annually silt removed is nearly 9 lakh c. f. t. This implies that total deposited silt is never removed as a result the capacity of the sewage system is decreased by 30—40%. So for better effici-ency of sewage system the silt removal system is to be revitalised.

Generally the rainy season in Calcutta lasts about 4 months in a year, and the annual rainfall is about 64 inches, as a result Calcutta is flooded 12 times in a year. Let us investigate the reason behind it.

The recurrence interval for Calcutta is taken to be as 2 months ; i. e. the sewer is supposed to equal or exceed its capacity 6 times within a year. Higher re-currence interval, if adopted, can accommodate a rain-fall of higher intensity consequently less chances of flooding in a given span of time. In this context we are to keep in mind another factor-the cost involved. Higher recurrence interval will definitely increase the capacity of the sewerage system but means extra cost. which we will possibly not be able to afford.

Acknowledgement :

We are greatly indebted to Prof. A K. Dutta and this article is written solely due to his inspiration.

HYDEL POWER PROJECT AND ROLE OF A CIVIL ENGINEER IN HYDEL POWER PROJECT

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Construction

Planning for power and its ensured ample supply has eluded many planner and today the power sector occupies a place of primary importance. Much has been said and written about power famine which grips most states paralysing the economy. The need to accelerate the construction of power projects has been rightly emphasized.

The sad state of present economy is mainly because of inadequate power supply to the industrial sector and as a result many industries have been forced to close down or operate at lower levels.

We can not allow this to continue. There is therefore an urgent need to re-examine our strategy for the sector.

Mainly we have two kinds of power project namely (1) Hydel power project (2) Thermal power project. India today produces 105 billion unit of power annually out of the 54% comes from thermal, 43% from hydro as 3% by Nuclear. By the end of 6th plan (1985) the installed capacity is proposed to be increased by 20, 262 MW. The targets being 13988 MW thermal, 5114 MW from Hydro and 1106 MW Nuclear.

So we see hydel power sources play a significant role in the aspect and major Civil Engg. works are involved here.

Most hydro electric sources are situated in the difficult and less accessible areas at the North and North East. The main item in this aspect is water. The potential energy contribution from the above sources is seasonal. Against the darw backs viz. high capital cost, the generation period is longer than that of thermal projects, hydel power projects has certain advantages viz. they utilize a renewable resources and have low operating cost. Also most hydel schemes are multipurpose projects, they not only generate power but are also needed for flood control and irrigation.

The hydro electric stations convert the energy stored in water into electric power by the use of (water) turbines coupled with generator. The water stored at higher altitude is allowed to impinge on the blades through penstroke and thus the potential energy (rather difference of level called head) and kinetic energy of water is first transformed into mechanical energy and then to electrical energy. Hence the continuous availability of water throughout the year is an ab olute necessity for proper operation of hydro electric stns. So, we see the analysis of availability of electric power also includes the study of rainfall, run-off and stream flow, available head and its limitations and facilities for storage and pondage.

Due to much less operating cost the hydro-electric power stns. as compared to thermal power stns. a considerable attention has been given to their development. Installed capacity of hydro electric power stns. is quiet high and of the 96 power stns., 53 have a capacity greater than 10 MW and average load factor of 38·8.

The hydro electric power stns. where it is to be installed, there an economical dam to store water at that selected site can be constructed. Although theoretically, it is possible to construct a dam at almost all places, preferably there should be high mountains on the two sides. The reservoir to be constructed should have large catchment area, so that the water in it should never fall below the minimum level.

High head is a major factor in the case. Specially if a high head is available, a site should be chosen in which a stream descending a steep lateral valley can be dammed and a storage reservoir formed.

The Salal hydro electric project envisages of an earthen and concrete dam to utilize a depth in lower reaches of the Chenab in Jammu and Kashmir to generate power from three units of 115 MW in the first stage and three units of 115 MW in the second stage. Foundation of concrete dam on complex geological formations posses a serious engineering challenge. The foundation is totally based on rocky materials. It has already been found that there exist many fossils. When str. is found over this kind of earth, the stn. will be collapsed definitely. But nothing will be understood from the top surface This is the most vital thing. Another way, foundation may collapse as soil is generally of shrinking and swelling in nature. Let us suppose foundation is formed after proper soil investigation. But after few years settlement may be noticed. So being a civil engineer one will have to be careful of it.

The Loktak hydro electric project in Manipur envisages inter basin transfer of water from the Manipur river to Leimatak lake and is expected to produce 105 MW of power through three units. The head race tunnel (6·65 km. long at Loktak) has possed a serious challenge to Civil Engineering skills as presence of explosive method gas was found in the rock fissures along the path of tunnel alignment. This is being tackled by mechanical cutters viz, Alpine miner and by deploying latest technology like NATM for the first time.

DIAPHRAGM WALL—ADOPTED IN METRO RAILWAY PROJECT

By

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5th year

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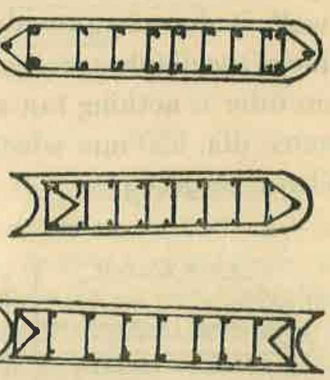
Introduction : After getting the alignment of the track for the Metro Railway by surveying work, the guide wall is provided at the ground level at the outer most boundary of the track i. e , at which the diaphragm wall is to be constructed.

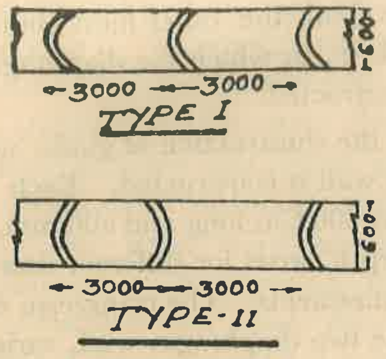
After the construction of guide wall the diaphragm wall is constructed. Each diaphragm wall is 300 Cm long and 600 mm. width and the depth varies for different sites as per design requirements. The transverse distance between the two diaphragm wall, varies place to place as per requirements. Railway track box is constructed in between the diaphragm wall after having a proper arrangement for the diaphragm wall. Diaphragm wall is generally ends 5000 mm. below the bed level of the box.



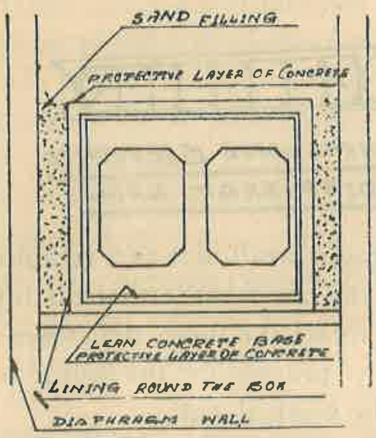
TRANSVERSE SECTION OF DIAPHRAGM WALL

Diaphragm wall acts as a retaining wall. It protect the box from lateral earth pressure and also protect the large structures near by the road by preventing the failure of earth surface of the vertical cut.

There are different formations of diaphragm wall according to the basis of the formation of key at the longitudinal end of each segment of diaphragm wall. This formations are known as primary and secondary which are shown in the Fig. below. Mostly Type I formation is



used for the construction of diaphragm wall at different construction sites. For some special circumstances the Type ll formation is used, such as it is generally used at the junction of two construction sites. The primary formation of semispherical shape at the side of the diaphragm wall is done by providing a form tube at the side of the diaphragm wall. [Form tube : A form tube is nothing but a cylindrical pipe of outer dia. 650 mm which is used in Metro Railway project]



Construction of a diaphragm wall :

i. A trench is made by means of grabbing

ii. Bentonite slurry is provided in the trench during grabbing for protecting the soil loss at the side of the trench

iii. Forming the reinforcement cage with proper positioning the sturt fixing plate and with proper bending for primary and secondary joint.

iv. Reinforcement cage is provided at the trench by the crane with a very great care so that the reinforcement cage must enter into the trench vertically, which is very difficult and if it is not vertical, then during the falling of the cage into the trench the reinforcement may be displaced.

v. Putting the cotrolled concrete by means of trimmy pipe with great care so that there is no separation between the concrete and bentonite slurry.

vi. After casting one diaphragm wall, another diaphragm wall is constructed adjacent to it after 7 days.

vii. According to the quality of the bentonite it can be reused for many times by doing a proper test on bentonite slurry in the site

Factors followed in designing the diaphragm Wall :

1) Earth pressure
2) Lateral pressure due to building surcharge.
3) Lateral pressure due to Road surcharge.
4) Lateral pressure due to crane working
5) Depth of penetration of supporting wall to ensure stability of bottom of cut against heaving.

Acknowledgement :—

Dr. S. C. Chakraborty, Department of Civil Engineering, B. E. College.

FUNDAMENTAL THEORY OF STIFF-ENED SUSPENSION BRIDGE

by
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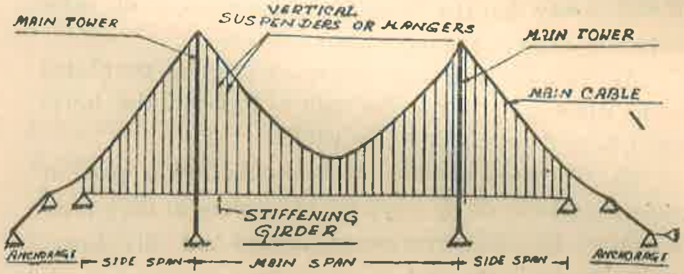
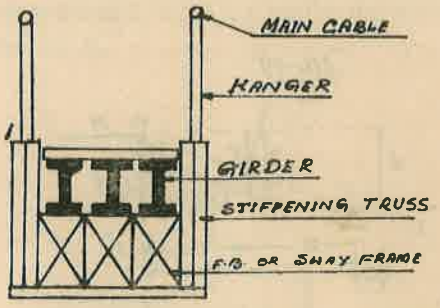


Fig. 1



END VIEW OF DECK

Fig-2

Introduction :

For economy design suspension bridge reigns supreme for spans in excess of 2000 ft. Bridges are stiffened with two or three hinged stiffening girders for long span and to reduce the sag under the rolling load. When the bridge is loaded with U.D.D.L. whole of the load is directly taken by the cables and the D.L.B.M. in the stiffening girder is zero. Longest bridge in the world : Verazano Narrows in New York. Its main span 4260' and carries 12 lanes of traffic.

Distinctive Feature :

1) Main towers are flexible and they may be regarded as pinned at both ends.

2) Generally cables are connected to the stiffening girders by vertical hangers, not by inclined hangers because it is difficult to maintain the hangers in tension under all loadings.

3) The stiffening girders are pinned at the towers.

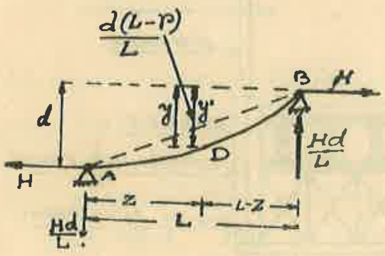
4) The cable is taken from anchorage to anchorage

in such a way that the horiziontal component of cable force is constant at midspan and sidespan.

5) In some structures cables are directly connected to the stiffening girder at midspan to transmit the horizonal force from girder to the cable.

6) The main cable is stiffened either by a pair of stiffening trusses or by a system of girders at deck level to control (i) Aerodynamic movement and (ii) Local angle changes in the deck.

Cable Analysis



When the load is vertical the real cable will be loaded in addition with horizontal reaction H with Co-existing reactions at A & B, where H & the cable profile must be such that the the total bending moment at any point of the cable is zero.

Let W = D.L./length of the deck

M_c = Cable bending moment due to W

Then in the real cable the total B.M. at D

$$M_c + \frac{Hd}{L}(L-Z) - Hy = 0$$

$$\text{or } y = \frac{M_c}{H} + \frac{d}{L}(L-Z) = y^1 + \frac{d(L-Z)}{L}$$

$$\text{So} \quad y^1 = \frac{M_c}{H}$$

Consider a particular case when d = 0 then

$$y = y^1 = \frac{M_c}{H} \;\&\; M_c = \frac{W}{2}Z(L-Z) \;\&\; y = \frac{WZ}{2H}(L-Z)$$

If the sag at midspan be f then

$$f = \frac{WL^2}{8H} \text{ or, } H = \frac{WL^2}{8f}$$

$$\therefore y = \frac{W}{2H}Z(L-Z) = \frac{4f}{L^2}Z(L-Z)$$

Thus the cable takes a parabolic shape

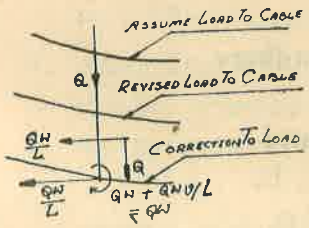
$$T_{max} = \sqrt{(R_a^2 + H_a^2)} = \sqrt{\left[\left(\frac{WL}{2}\right)^2 + \left(\frac{WL^2}{8f}\right)^2\right]}$$

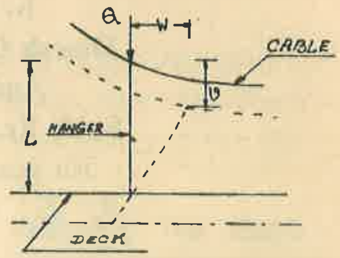
$$= \frac{WL}{8f}\sqrt{\left(16f^2 + L^2\right)}$$

Tower Analysis :

If the live load extends across the width of the roadway the tower deflects. If the loading is on the one side of the roadway or during torsional oscillations of the structure tower also twist. The analysis may be done by assuming the tower as a portal frame. A pure torsional mode results in equal and opposite deflections of the hangers on either side of the deck at a given spanwise location. The primary problem is the calculation of tower stresses due to these deformations. The tower departs from a vertical plane, causing large vertical loads to become eccentric, producing bending and twisting moments and stresses. It may be necessary also to estimate the transverse and torsional stiffness of the axially loaded tower.

Correction for shifts in Cable Loads :





DEFLECTED POSITION SHOWN BY DOTTED LINE

The additional loads consist of a couple and horizontal force QW/l, this additional load will produce an additional dM_c and the vertical deflection of the cable v can be computed from

$$v = \frac{dM_c}{H+h} - \frac{h}{H+h}y^1$$

h=hanger force ; H & y^1 are discussed before.

Aerodynamic Instability :

Aerodynamic forces cause damage giving rise to the oscillations in the suspension bridge. In modern practice this analysis is done by using a vibrating sectional model. The wind forces on the deck are influenced by

a) Wind velocity

b) The shape and size of cross section

c) The nominal angle of attack

d) The motion of the deck

Damping : If the structure is inelastic of forms a nonconservative system, work must be done to maintain periodic motion.

Flutter : A bridge deck may oscillate in a mode including both transverse displacement and torsional rotations. For this to happen $\frac{N\Theta}{N_v} \rightarrow 1$, $N\Theta$ =torsional frequency (N_Θ & N_v can be found out by sectional model analysis)

N_v = Vertical frequency

Torsional movements cause twisting of both the deck and the tower. For design $\frac{N\Theta}{N_v} > 1$.

Stiffening system is done as shown in Fig. 2 to prevent the torsional effect on the deck.

Design Informations :

Side / main span ratio : Uptil now this ratio has been kept in between .17 (George Washington) & .50 (Mackinac bridge). This ratio controls the angle of the cable as it meets the deck near the anchorage and may affect the anchorage design in case of ratio .5 the slope would be zero.

Main span / sag ratio :

This ratio has a direct influence on (a) Cable (b) tower (c) hanger length.

A smaller sag increases the cable tension lifts the vertical reaction at the tower unchanged but reduces the length of tower and hanger. Cable flexibility is proportional to the sag. A reduced sag increases the cable stiffness and hence the total stiffness of the structure.

Depth of the stiffening system :

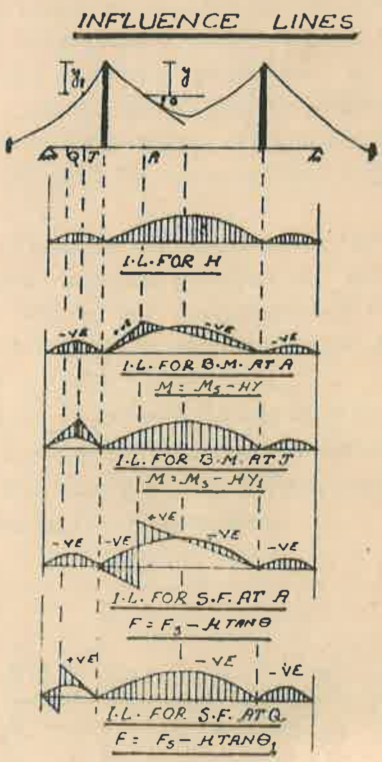
A lower bound on depth may be set by the need to control grade changes in the deck. A reasonable vertical radius of curvature for highway design is 10,000 ft. For a steel member in bending, the stress at a destance y from the neutral axis is

$$S = \frac{Ey}{R} \quad E = 30 \times 10^3 \text{ KSi} \quad R = 10{,}000 \text{ ft.}$$

$$S = 18, \text{ KSi}$$

$$\text{Therefore, } y = \frac{SR}{E} = \frac{18 \times 10{,}000}{30 \times 10^3} = 6 \text{ ft.}$$

For a dymmetrical truss or girder the limiting depth would be 12 ft.



Design moment varies approximately as I :

Many suspension bridges have been designed on the basis of an initial span / depth ratio. So initially select a truss depth and chord area will give prechosen moment of inertia I, as well as carrying max moment at the specified truss.

For a truss $I = \frac{Ad^2}{2}$ A = area of the chord

d = truss total depth

$$S = \frac{M}{IY} = \frac{M}{\frac{Ad^2}{\frac{2}{\frac{d}{2}}}} = \frac{M}{Ad}$$

$$Ad^2 = 2I \quad \ldots (1) \text{ and } Ad = \frac{M}{S} \quad \ldots (2)$$

Dividing (1) by (2) $d = \frac{2IS}{M}$

and $A = \frac{M}{Sd} = \frac{M^2}{2IS^2}$

or, $M = (\sqrt{2IA})\ S = (\sqrt{2A})\ S \times \sqrt{I}$

$\therefore$ M is proportional to I

Reference : 1) Design of superstructure-Colin O'Conor

2) Civil Engineering Handbook U. S. A.

3) Theory of Structure-Vol-II-Vazirani & Ratwani.

" Faith is the force of life "

—Tolstoy.

Computer Program For Moment Distribution Method

Anup Kumar Mukherjee & Ranjan Palit
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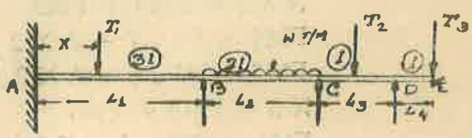
In the design of any structure in civil Engineering, it may be required to find out the moments at the different supports on which the whole structure or part of the structure is rested in position. Finding out of the different support moments is a tedious and time consuming job besides other important calculations in the design problem. So to find out the support-moments by easy means we can take the help of a computer. At first a programme must be prepared with a few datas (required to solve the problem) as input to the computer. After a few seconds the computer will print the results of the problem. The programme prepared can be used again for any set of data by just changing the data cards.

Let us consider the programming for finding out the different support moments by the method of 'Moment Distribution'. Language used for programming is FORTRAN IV suitable for TDC-316 computer (installed in B. E. College)

A loaded beam with definite supports at different points is shown here. We are interested in this case to find out the moments at the different supports A, B, C & D by the help of the computer.



The load T_2 is acting at a distance X_1 from C

FORTRAN STATEMENT

```
C — — — —      — — — Program to compute the moments
C — — — —      — — — At supports by the method of
C — — — —      — — — Moment distribution
               REAL L1, L2, L3, L4
               READ (7, 101) T1, T2, T3, L1, L2, L3, L4, X, X1, W
    101        FORMAT (10F8.2)
               D1 = 0·0
               D2 = 12·0 ★ L2 / ( ( 12·0 ★ L2 ) + ( 8·0 ★ L1 ) )
               D3 = 8·0 ★ L1 / ( ( 8·0 ★ L1 ) + ( 12·0 ★ L2 ) )
               D4 = 8·0 ★ L3 / ( ( 8·0 ★ L3 ) + ( 4·0 ★ L2 ) )
               D5 = 4·0 ★ L2 / ( ( 4·0 + L2 ) + ( 8·0 ★ L3 ) )
               D6 = 1·0
               D7 = 0·0
               FM1 = ( – T1 ) ★ X ★ ( ( L1 – X ) ★ ★ 2 ) / ( L1 ★ ★ 2 )
               FM2 = ( + T1 ) ★ ( X ★ ★ 2 ) ★ ( L1 – X ) / ( L1 ★ ★ 2 )
               FM3 = ( – W ) ★ ( L2 * * 2 ) / 12.
               FM4 = ( + W ) * ( L2 * * 2 ) / 12.
               FM5 = ( – T2 ) * X1 * ( ( L3 – X 1 ) * * 2 ) / ( L3 * * 2 )
               FM6 = ( + T2 ) * ( X1 * * 2 ) * ( L3 – X 1 ) / ( L3 * * 2 )
               FM7 = ( –T3 ) * L4
               ITERM = 0
               SUM1 = FM1
               SUM2 = FM2
               SUM3 = FM3
               SUM4 = FM4
               SUM5 = FM5
               SUM6 = FM6
               SUM7 = FM7
    51         FM1 = D1 * FM1
               A X 1 = FM2 + FM3
               FM2 = D2 * ( – A X 1 )
               FM3 = D3 * ( – A X 1 )
               A X 2 = FM4 + FM5
               FM4 = D4 * ( – A X 2 )
               FM5 = D5 * ( – A X 2 )
               X 3 = FM6 + FM7
               FM6 = D6 * ( – X 3 )
               FM7 = D7 * ( – X 3 )
               SUM1 = SUM1 + FM1
               SUM2 = SUM2 + FM2
               SUM3 = SUM3 + FM3
               SUM4 = SUM4 + FM4
               SUM5 = SUM5 + FM5
               SUM6 = SUM6 + FM6
```

```
      SUM7 = SUM7 + FM7
      AI = FM1
      FM1 = 0·5 * FM2
      FM2 = 0·5 * AI
      AI1 = FM3
      FM3 = 0.5 * FM4
      FM4 = 0·5 * AI L
      AI2 = FM5
      FM5 = 0·5 * FM6
      FM6 = 0·5 * AI2
      SUM1 = SUM1 + FM1
      SUM2 = SUM2 +FM2
      SUM3 = SUM3 + FM3
      SUM4 = SUM4 + FM4
      SUM5 = SUM5 + FM5
      SUM6 = SUM6 + FM6
      SUM7 = SUM7 + FM7
      ITERM = ITERM + 1
      IF ( ITERM. LE. 6 ) GO TO 5I
      WRITE ( 8, 102 ) SUM1, SUM2, SUM3, SUM4, SUM5, SUM6,SUM7
102   FORMAT ( 5X, 7F 7·2 )
      STOP
      END
```

Acknowledgement : **Dr. Suman Dasgupta** Department of Civil **Engin-**
eering, B E. College.

"Heaven must be in me before I can be in heaven".

—Stanford.

CABLE STRUCTURE

by

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Structural forms may be classified into the following two catagories according to the dominant stress conditions under their maximum design loads.

i) **Uniform Stress Form :** In this case, stress is uniform over the depth of the member or over the thickness of panel, as for example, cables, arches, truss members, etc.

ii) **Varying Strees Form :** In this case, stress varies over the depth or thickness usually from a maximum tensile stress at one surface to a maximum compressive stress at the other, as for example, beams, rigid frames, slabs, plates etc.

Since uniform stress forms utilize the available strength of the material more efficiently than the 'varying stress form' a structural engineer will obviously adopt a 'uniform stress form', if functional requirements are fulfilled.

Now, let us come to the point why and where cable structures are used.

Among the 'uniform-stress forms', 'Cable' is the most simple and efficient structural form which takes the shape of a 'catenary' (for simplicity it is assumed to be parabolic) due to its own distributed dead load as shown by solid line position in fig (a).

Fig (a)

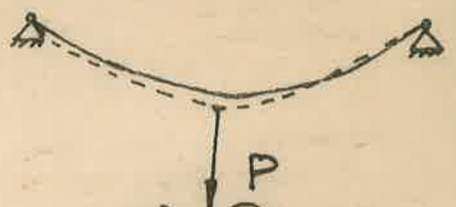

Fig-(b)

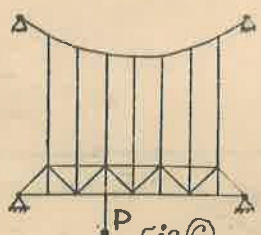

Fig (c)

Cables are almost perfectly flexible. It may be assumed that they have no flexural strength (no resistance to bending) and they are not subjected to different varying parameters such as B. M., S. F., torsion etc. except tension. As a result, they must adjust their shape to conform to the equilibrium polygon of loads applied to them . The adjustment in shape is a significant geometrical change in shape, not only due to the small deflection resulting from the stress-strain characteristics of deformable bodies.

As shown by the solidline position in fig (a), a cable has the shape of catenary under its own dead load. If a large load P as compared to its own dead load is now imposed on the cable, it takes the shape as shown by the dotted line position which is substantially two straight line segments. On the other hand, as shown in fig (b), a load P, small in comparison to the weight of the cable would cause only a very small change in shape of the cable.

Sometimes the passage of a very heavy moving load across the span, would produce continuos alternation in the shape of the cable which would result large deformations and oscillations in the road way. To over come this difficulty, the bridge deck is stiffened by using stiffening girders, so that the concentrated load is more or less equally distributed along the cable (see fig (c), and the changes in shape remains within the tolerable limits.

The principle is clear, from the consideration of the equilibrium of a small portion of the cable. A cable can maintain both vertical and horizontal equilibrium simultaneously by

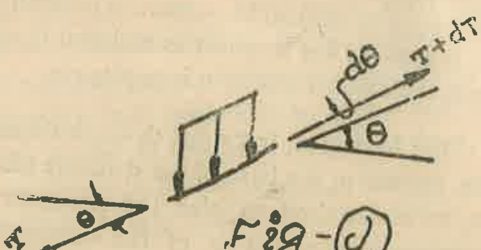

Fig-(d)

(1) changing its tension

(2) adjusting its slopes.

From the above discussions, we find that the analysis of cable structures is much simpler than any other structural form.

Cables are used i many important types of structures. They constitute the main load carrying elements for suspension bridges and cable car systems. They are used extensively for permanent guys in structures like derricks and radio towers etc.

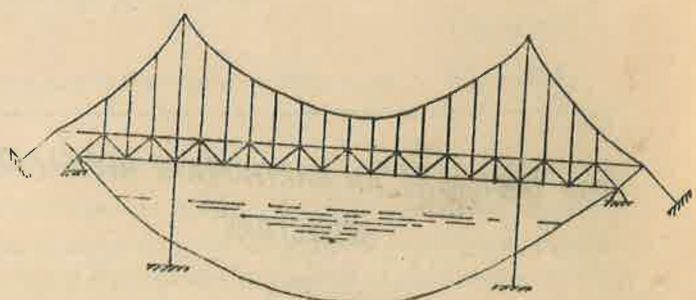

Fig-(e)

In the long span structures such as in suspension bridges, fig (e), the B. M. is reduced by providing partial supports at points along the span by means of a system of cables. A suspension bridge is usually erected in such a manner that the dead loads are carried by the cable. When live load is applied to such a structure, tension in hangers transfer a large portion of live load to the cables. Hence the stiffening truss is not subjected to any dead load or live-load moments.

For long span structures, this is of particular importance, as a huge amount of load is carried by the cable in tension, which is really a highly efficient manner of carrying loads.

Acknowledgement : **Prof. P. K. Gayen** Department of Civil Engineering, B. E. College.

FOR DESIGNING AN EARTHQUAKE RESISTANT STRUCTURE

By

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and

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In a region of high seismicity, important structures are designed to withstand all but the most severe shocks. It undoubtedly represents one of the most severe demands that may be made on the skill of a structural engineer. Major earthquake is the most severe loading to which tall buildings, dams, bridges, tunnels, towers, chimneys etc. might ever be subjected to ; yet the probability of its occurrence during the life of the structure is very low. This combination of extreme load and unlikely occurrence demands, that special design strategies are to be adopted.

For designing an earthquake resistant structure the starting point should be the specification of the nature and intensity of the maximum ground motions which it must be able to resist. The motions are vibration waves emanating from an energy source and propagating through the earth's crust. Although the local mechanism of earthquake generation is reasonably well understood, it is not possible at present to predict the time or location of future earthquakes. So when we are going to design an earthquake resistant structure, the geological investigation is a must to identify the active faults in the local geological structure which might be the sources of future earthquakes combining the geological and historical information, an estimate is made of the magnitude and epicentral location of the earthquakes which cause significant shaking at the structure site, and also return period or recurrence interval of the events associated with each indentifiable fault.

The earthquake sets up primary, secondary, Raleigh and love waves in the earth's crust, the vibration being both in horizontal and vertical direction. The horizontal movement is however much larger than the vertical from nine to ten times as large and may of course be in any direction. Consequently almost all the damages caused to a structure is accountable to this horizontal motion. The vertical movement is generally very small and because of the structure is designed to resist vertical loads, the damage due to it is neglegible.

The horizontal force due to an earthquake is therefore, applied at the base of the structure and is equal to the force required to give the structure a horizontal acceleration equal to that of the surrounding ground. The magnitude of this force is given by the formula :

$F = \frac{aw}{g}$, where F is the force due to shock, a is the horizontal acceleration due to the quake, w, the weight of the structure and g is the acceleration due to gravity. For computation of earthquake forces for design purposes, the selection of acceleration must therefore, be made with reference to the intensities of the severer shocks which have occurred in the locality in which the structure is to be built. 'Rossi-Forel rating' classifies different intensities of earthquakes according to the severity and extent of damage. The ratings also provide values of acceleration in terms of 'g' for various types of earthquakes.

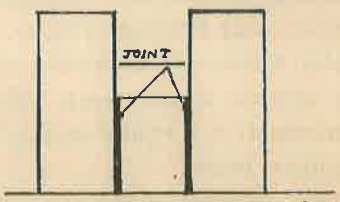
For building and dams following types of earthquake are important.

Class of Intensity	Effect	Acceleration
7.	Strong shock ; fall of plaster but no real damage to buildings	0.02g to 0.05g
8.	Very strong shocks ; cracks walls, breaks chimneys, produces slight crack in the ground.	0.05g to 0.1g
9.	Extremely strong shock, uproots buildings, causes bed cracks in the ground or land slides.	0.1g to 0.2g
10.	Shocks of extreme intensity resulted total destruction in the region of occurrence	0.2g to 0.3g

Again there are world maps which are divided into different zones according to the severity of possible earthquake in the area. India can be divided into five zones ; a detailed map of these zones is given in the I.S. 1893-1975. Calcutta belongs to zone III and its seismic coefficient is 0.04.

When horizontal forces have decided on, the stresses can be computed in a manner similar to the determination of wind stresses. The overturning moment due to a lateral forces F is $M = Fy = \frac{aw}{g}$ y, where y is the vertical distance of the centre of gravity of the structure (or of the portion of the structure above the horizontal section considered) above the base.

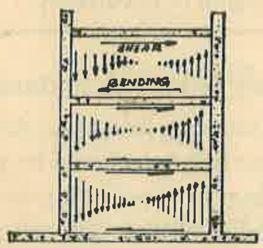
Buildings should be designed to resist lateral forces from any direction because of an earthquake may occur in any direction. The earth movement, however, can be replaced by two components acting parallel to the axes of the building, therefore, it is significant to investigate its strength in two perpendicular directions. It is desirable that the height of a building be uniform. In plan a closed shape, preferably square or nearly square is desirable because these shapes tend themselves most easily to symmetrical bracing. However. unsymmetrical shaped building may be built to withstand earthquakes provided they are properly designed. Adjacent buildings or parts of the same building should be sufficiently separated to prevent them from pounding one another during an earthquake because of their different phase of movement. This can be accomplished with special joints. These joints are sometimes called crumple, The separation should be carried down to the top of foundation.



SEPARATION OF ADJOIN BUILDING

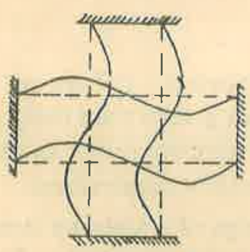
Again fire frequently follows an earthquake and its ranges are often greater than those of the quake. The fire reinforced concrete makes its use doubly desirable in earthquake resistant construction.

In the design of a high rise structure one can select a frame with rigid connections, a frame with bracing, a structure carrying lateral forces primarily by deep walls or shear walls or a combination of these elements. Because of the inter-relation among flexibility and strength of a structure and the forcc generated in it by earthquake motion, the dynamic design procedure must take these various factors into account. The idea to be achieved is one involving appropriate flexibility and energy absorbing capacity, permiting the earthquake displacements to take place without unduly large force being generated. Thc attainment of ductility required to resist earthquake motion, must be emphasised. In the figure below the distribution and magnitude of stresses caused in a wall by the downward transmission of accumulated lateral forces is shown diagramatically. If the wall thickness is uniform, both shearing and bending stresses will increase in the lower stories.



ACCULATED SHEAR AND :
BENDING STRESS DUE TO EARTH MOTION

In studying the performance of the steel structures three basic structural elements are involved : (i) Beam Column connection (ii) Bending capacity of beam and girder and (iii) Column compression and bending. The beam and column displacements associated with unit joint displacements in a typical portion of the frame is shown in the figure below.



TYPICAL DISPLACEMENT OF BLDG JOINT

The cast-in-situ reinforced concrete may be designed to be ductile and have greatwork capacity prior to failure. The cast in situ concrete structures which were damaged by earthquakes previously are analysed in the light of current knowledge and a great deal of inadequate design and construction have been exposed. In most cases where damages occur, there is no specific earthquake resistant design and in some cases seismic provisions are in adequate. In modern time 'Ductile Concrete' (D. C.) is used. Unfortunately, no building of modern D.C. design have been exposed, infact very few have yet been designed and so that record does not yet exist. But there is every reason to believe that when both good seismic design practice and D.C. requirements are fulfilled along with good construction, the result would be quite satisfactory.

Prestressed concrete differs from conventionall reinforced concrete in the introduction of internal stresses by tensioning the steel and holding it against the concrete. For buildings of materials such as steel or reinforced concrete most building code permits a 1/3 increase in the allowable stresses when considering earthquake loading. Consider the case of allowable tension in prestressed steel, which is usually set at 0.60 f's a one third increase wouod raise this to 0.80 f's, which is clearly must too high. Hence, a straight one-third increase for allowable stresses can not be specified when considering earthquake effects in prestressed concrete. It assumes that all members would be able to carry an one-third increase in load for a short duration without signs of distress ; this is a valid assumption for prestressed concrete, as in the case of other conventional materials when designed according to the usual standards. It is suggested that the loads, shears and moments be modified by a reduction factor of 3/4 when considering earthquake effects while the allowable stress remains unchanged.

In the design of a multistoreyed building two problems are paramount. The distribution of shearforce among the various vertical resisting elements of a building and the action of these elements when subjected to dynamic lateral force. The shearforce distribution is dependent on the elastic properties of various resisting elements and is usually analysed assuming rigid horizontal diapharms.

The improvement of modern traffic system require in certain localities that major bridges be constructed across coastal regions which. when located in active seismic regions, present an extremely difficult design problem due to poor foundation conditions usually present under such conditions, the bridge piers are normally supported on piles and since structural types such as buildings also may he supported in this manner, the seismic response investigation can be considered a case study of the seismic effects on pile supported structure. If the base medium below the clay layer has much higher stiffness and strength characteristics than clay medium and if the piles are driven on appreciable distance into this medium, at the interface of these two media large discontinuity in soil shear strains would likely cause curvature in the piles that far exceeds their yield values. Thus, in effect plastic hinges would be developed in the piles at this location. But the vertical load carrying capacity should not be lost in that locations.

The bridge superstructures including attachments to piles should be designed with full recognition of the importance of providing ductility so that large amount of energy can be absorbed during the period of very strong earthquake. Since the phase relations of the dynamic response of the bridge deck will differ from one section to the next, adequate seperation should be provided in the expansion joints so that one section of bridge deck will not 'pound' against the adjacent sections during the period of strong earthquake.

Due to horizontal acceleration of the foundation and dam there is an instantaneous hydrodynamic pressure exerted against the dam in addition to hydrostatic forces. The direction of hydrodynamic force is opposite to the direction of earthquake acceleration. For the design of dams, earthquake forces shall be considered in addition to the hydrodynamic pressure. The horizontal seismic coefficient at the top of dam reduced linearly to zero at the base and the vertical seismic coefficient may be taken as half of the horizontal seismic coefficient. A vertical acceleration changes the weight of the masonry and the water in the same ratio. For a gravity dam, reservoir full, the most unfavourable direction is uprstream normal to the axis. The corresponding force acts downstream. For reservoir empty, a downstream acceleration is more unfavourable.

In the design of a structure to resist earthquake motions, the designer works within certain constraints, such as the architectural configuration of the structure, the foundation conditions, the nature and extent of hazard that should occur, the possibility of an earthquake, the possible intensity ot earthquakes in the region, the cost and available capital for construction and similar factors. In the light of available informations the designer chooses the materials and he must have to follow the code for safety of the structer. Actually code represents relatively small earthquake which has a rather high possibility of occurrence duringthe life of the structure and this level of intensity is probably all that can be economicaliy justified for the design of typical structure. However, the major problem facing the designer is to ensure adequate ductility in his design, so that the unlikely (but still possible) major earthquake, which might occur, will not cause disaster.

References

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2. Indian Standard Code of Practice for Structural safety of buildings ; loading standards (I. S. 876—1964)
3. Indian Standard criteria for earthquake resistance design of structure (IS : 1893—1975)
4. Earthquake Engineering by Robert L. Weigel (co-ordinating editor)
5. Earthquake Resistant Design of tall Buildings by Ray W. Clough.

Acknowledgement

1. Dr. D. Mukherjee, Deptt. of Applied Mechanics, B. E. College.
2. Dr. P. K. Ray, Deptt. of Civil Engineering, B. E. College.
3. Dr. S. Roy, Deptt. of Mining Engineering, B. E. College.
4. Sri S. Ghosh, Deptt. of Civil Engineering, B. E. College.

Defects In Rail Sections

by
Pranab Talukdar & Rupak Sarkar
5th year C. E. B. E. College.
Department of Civil Engineering.

The reasons for rail failures are mainly defects in rail sections. Rail defects govern the servicc life of rail and its carrying capacity, axle loads, speed potential and cost of track maintenance. Manufacturing defects and fatigue of matal due to rail defects are responsible for largest number of rail failures.

Defects in rails can be broadly divided into four categories :—

1) Design defects
2) Inherent defects
3) Rolling defects
4) Service defects

A brief discussion on these defects are given below :—

1) Design Defects :

Defects which creep in due to design are many. Some of them are :—

i) Insufficient head depth
ii) Improper head width
iii) Improper upper and lower fillet radii
iv) Defective top table radii
v) Improper fishing planes and angles
vi) Incorrect location of fish bolt holes
vii) Less foot width
viii) Thinner Web etc

The difficulties which are caused due to these defects are discussed below :—

i) Insufficient head depth : Insufficient head depth will permit hardly any metal in the head of the rail to wear. This will result in reduced service life of rails or may lead to grazing of the fish plates at an early date.

ii) Improper head width :—

If the head width is more than the required one, there will be eccentricity of the load transmitted by the wheel which in turn will cause localised fillet and web stresses and high cooling stress in the rail sections.

To narrow a head will develop end better quickly, provide insufficient contact area to the wheel tread and will not manufacture better due to early cooling than other parts of rail.

iii) Improper upper and lower fillet radii :

The stresses in the fillet are inversely proportional to the radius of the fillet curvature. At upper fillet, stresses are increased due to eccentricity of the load. The compressive stresses are induced on that side of the web to which the eccentricity of load lies. If we increase the thickness at the junction of the head and web by increasing the fillet radius this problem may be solved.

From the experimental measurements of of web and fillet stresses it has been fonnd that the large stresses occur near the bottom of the web fillet. We can reduce these large stresses by increasing the thickness of the web or the fishing angle.

iv) Defective top table radii : –

The top table radii of the rail should as far as possible be very near to the average worm wheel profile. The difference in top table radii and worm wheel profile would result in rough riding and flow of metal of the rail head on gauge side resulting in shelly spots and head checks.

v) Improper fishing planes and angles .—

There will be uneven 'draw in' of the fish plates which tends to bend the rail web if there is unequal fishing planes. Greater fishing angle reduces the danger of the fish plates "freezing and cooking" the joint but will induce extra stresses in the web. The life of the fish plates are reduced by the smaller fishing angle. Smaller area provided in the fishing plane surfaces result in quick wear of the fish plates which in turn result in loose joints.

vi) Incorrect location of fish bolt holes :—

Most of the rail failures occur through the bolt hole near the rail ends within the fish plate region. The cracks generally start at the periphery of holes and project in a direction at 45° to the longitudinal axis of the rail. At the bolt holes and the upper and lower fillets high tensile stresses are produced in the vertical direction when the fish bolts are tightened.

vii) Less foot width :—

It makes the rail laterally very weak and result in overturning of rail when subjected to a higher lateral loads. The load will distribute over a smaller area due to insufficient foot width which in turn will produce excessive stresses in the sleeper at the extreme edges of the rail. This excessive stress will damage the sleepers.

viii) Thinner web : Thinner web is not sufficient to bear and transmit all the load to base without cripping.

2) **Inherent Defects :**

The main inherent defects are :—

i) Inclusions
ii) Unsatisfactory micro-structure
iii) Piping
iv) Segregation
v) Banded rail
vi) Unsatisfactory chemical composition

The other minor inherent defects are 1) kind of steel, 2) splashing, 3) blow holes, 4) over heated or burnt rail, 5) draw holes, 6) process of manufacture, 7) liquation 8) nodules, 9) internal stresses due to cooling,

10) vertical head split, 11) horizontal head split 12) web split 13) foot cracks 14) rokes etc.

These inherent defects have their origin in the manufacture of rail steel and are not visible. The reasons behind these main inherent defects and the difficulties which are caused due to these defects are discussed below :—

i) Inclusions :—

Occasionally it happens that rail steel manifests great no. of non metallic particles in the form of small granules due to the portion of slag. As a rule slag is more harder and brittle than steel. The inclusion are, therefore, foreign bodies and can be specially dangerous at places, where steel is subjected to crushing stress, i. e. on running edge of the rail line. High rail pressure acts upon a depth of 8 to 10 mm. When the steel flows, there arises a point where slag impurities crack which gradually spread out in the form of fatigue fracture and becomes visible on exterior surface and track coloured flakes occur After few years, with increasing wear of rail, we can definitely anticipate cracking at this points of running edges and rail become inservicible. The corelations are evident. Slag inclusion can be recognised easily. Laying of rails with such defects in heavily loaded sections should be prevented.

ii) Unsatisfactory micro-structure :—

Fineness and uniformity of grains govern the mechanical property of the steel. The grain size is directly proportional to the finishing temperature at the time of manufacture. Smaller grain size steel makes better rails. Defective microstructure may result in banded rails, overheated rails and burnt rails.

iii) Piping :—

Molten mass of ingot while solidifying cools at exterior surface (surface which is in contact with mould) first. This contraction tends to draw steel from the central portion of the ingot and funnel shaped cavity is formed in the rail which gets oxidised and does not weld during rolling. The process by which this type of cavity is formed in the rail is known as piping and the rail with this type of defect is known as piped rail. In the piped rail at first we find a vertical spilt in the rail web and then a depression at the rail head. This reaches the stages of split, at the pipe portion. Piped rail should be removed immediatly when noticed.

iv Segregation--Failure of elements of the steel to mix uniformly is called segregation. This alters the characteristics of steel completely and makes it either hard, soft or brittle. Segregation is due to non-uniform cooling. Quick and controlled cooling reduces segregation. The rail with such defect can not be used.

v) Banded rail —

Segregation of nearly parallel band in the direction of rolling may occur in rails. This is due to use of banded rail steel which consists of continuous alternate bands of ferrite and pearlite. Premature fatigue may occur in rails made of banded rail steel due to that endurance limit of ferrite is lower than pearlite. The rails with such defect must be avoided.

vi) Unsatisfactory chemical composition :

Different chemical compositions in rail steel have different properties such as tensile strength, elongation, wear, resistance.

More of carbon adds hardness and more of manganese gives strength and toughness. Proper chemical composition should be made to have the desired property of the rail steel and this will avoid many of the inherent defects.

Rolling Defects :

The defects due to rolling are known as rolling defects The main rolling defects are :

i) Roll marks

ii) Collar marks

iii) Guide marks

iv) Overfills and underfills

v) Fins

vi) Silver

vii) Thermal flaws etc

The other rolling defects are seams, lap, flakes, rocking foot, tolerances etc. The reasons behind these main rolling defects and the difficulties which are caused due to these are discussed below.

i) Roll marks : Due to defects in the rolls, while rolling the rails, longitudinal service defects are formed. Such defects are named as roll marks.

ii) Guide marks :--During rolling and even after rolling in the rolling mills, the rails are guided by metallic supports to pass from one roll to other. The finished products, from rollers are struck or guided by the guides. This sometimes usually causes permanent straight marks on rails surface in the longitudinal direction of rolling. These marks are called guide marks.

iii) Overfills and underfills :—By overfills it is meant that the rails will have more dimensions and thereby more metal due to poor design of rolls, and incorrect adjustment of rolls. By underfills it is meant that the rails will have less dimensions due to same reasons. The rails with such defect can not be used because we require rail sections with a uniform cross section.

iv) Fins :—A protrusion to a rolled rail in the surface formed during rolling is called fin. Fins may occur due to overfill, wear of rolls, collaring of pieces of rolls or defective groove in rolls.

v) Silver :—Separate mass may overlap the head or foot of the rail. This overlapping of separate thin tapered metal is called 'silver'. Silver on the head of rail may crack loose and get dislodged leaving in indentation on the surface.

vi) Thermal flaw :—Rolling mills try to roll the rails at very high temperature to boost out their production. This rolling of rails at very high temperature develop a flaw in the rail. Rails get decarborised zone on the surface. Top head of rail wear out very quickly. Other thermal defects such as internal stress may also develop in rails rolled at very high temperature.

Service defects : The defects which are formed during the service life of rails are known as service defects.

The main service defects are :

i) End batter ii) Flow iii) Head crush iv) Shelling v) Nicking vi) Web failure vii) Defective weld viii) Corrosion etc.

i) End batter :—It is hardly possible to lay the joint of rails with plates without any gap in fishplate and rail. Any gap between the fish plate and rail ends at joint will cause the depression at one end of the rail when wheel comes on it. The wheel will then give an impact on the adjoining rail end. This impact will cause the sharp edge of the rail to be hammered down. This is called end batter.

ii) Flow :— Metal from rail head top may flow and overhung at the sides of the head, resulting in widening of rail head and depression. It occurs predominantly on a curved track. The main causes of such defect are soft metal at the surface of rail head, slippage of wheels, blow holes, improper heating of ingots while rolling.

iii) Head crush :—Crushing of head with out the sign of crack below, will flatten the rail head. These normally originate from a soft spot in the rail steel in head which gives way under the impact of flat-tyre, higher speed or heavy loads. It may also develop at the rail ends because of weak joints, due to poor fish plates, poor support of sleepers and loose fish bolts

iv) Shelling —Progressive horizontal separation of rail metal at the gauge face corner is called shelling. It becomes evident by blaek spots appearing in the rail head at the zone of separation in a piece of metal breaking completely leaving a cavity in the rail head. It is normally caused by heavy pressure over a small area of contact. This defect normally occur on outside rails of sharp curves.

v) Nicking :—Nicking is developed due to running of flat wheel over the rail top. Deep nicks may cause other defects which may cause other defects which may lead to rail failure.

vi) Web failures :—Over stressing of bolt holes may result in web failures.

The other causes can be a hammer blow used for striking the dog spikes. The holes made by signal branch with a torch, get burnt sometimes.

vii) Defective weld :—Improper fusion of welding or surface cracks developed by heat of welding may result in separation of rails welded together. The defect may also develop due to inclusion during welding. The defect is not visible till the rails separate and a crack becomes visible. This defects at joints may prove to be serious due to large gaps developing in winter and buckling of rails in summer.

viii) Corrosion : Deterioration of metal by chemical or electro-chemical reactions with the atmosphere of sea-coast, industrial area, moisture etc. is called corrosion. This is a serious defect.

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3) Railway Engineering by Garlow & Pasternov

THE BUDDING CIVIL ENGINEERS 1980-'81

Soumitra Roy
Professor Para Silchar-5
Assam. Pin - 788 005

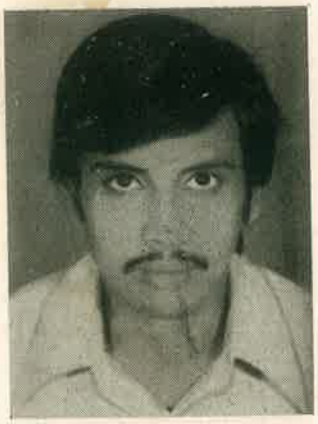
Indifference makes him 'Jali' to a great extent.

Pranab Talukdar
28, Goalapara Road.
P.O.-Parnasree Pally
Calcutta - 700 060

What a luck ! 59 lovers at a time !

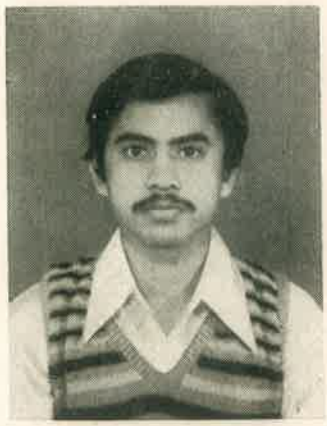
Sujit Mukherjee
44, Lake Temple Road,
Calcutta-29

The prince of Bengal finds no charm in Hostel life.



Sanjib Chakraborty
P.O. Agarpara, Kalyanpur
Dist. 24 Parganas,
West Bengal.

Our 'Bachha' cries to be adult.



Asim Ghosh
76A Ibrahampur Road,
Calcutta-32.

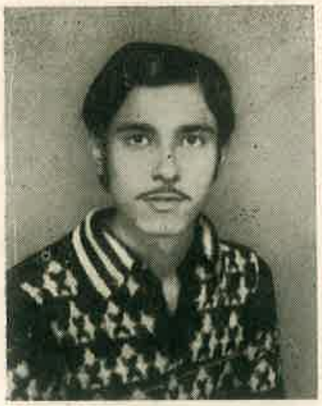
Popularly Known as NH, KUT, CB, GM. (Guess what !)

Ranjan Palit
CD-184
Salt Lake,
Calcutta-64.

Danger, - 440 Volts ! Copy-right preserved.

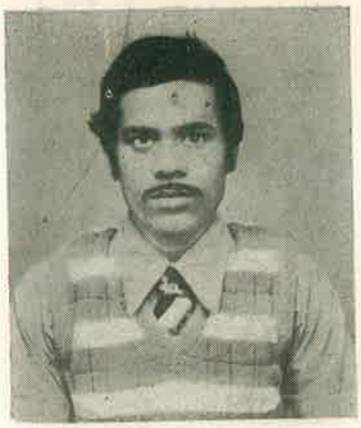
Dinesh Ch. Chowdhury
Chowdhuri Para.
Andul, Howrah.

The real success of life lies in Love.



Rupak Sarkar
20 Dum Dum Road,
Block GA/5
Calcutta-700 030

Enjoy to-day because tomorrow we will die.



Subir Garai
22/3Q Sree Nath Mukherjee
Lane, Calcutta-30.

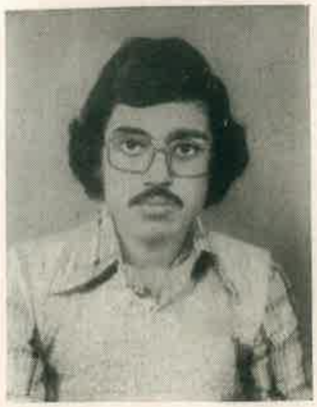
Attached toilet is essential for an examinaticn hall

Agnimitra Bhattacharya
F2/13, Labani Estate
Salt Lake City, Cal-64

If music be the food of Love, play on.

Utterly Butterly Delicious
'The Amul-Butter'.

Biswarup Das Purakayastha
21/2A Mahesh Dutta Lane
Chetla, Cal.-27

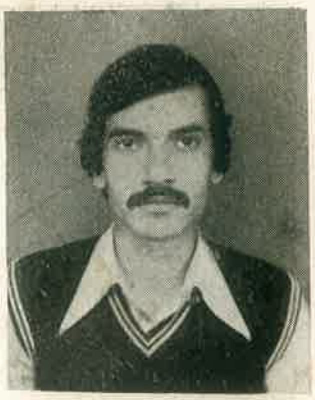


Saibal Ghosh
108, Executive Hostel
Lala Rajpat Rai Road,
Durgapur-4

Laziness,-is his greatest asset.

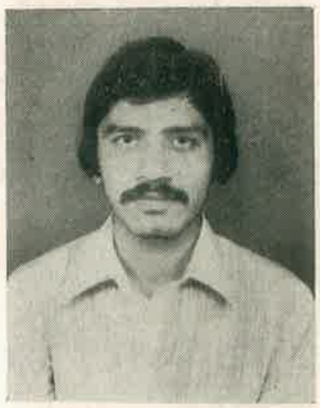
Our Captain's bowling figure :-
21 overs, OM, 123R, OW.

Debasish Ghosh
3, Pearimohan Ray Road,
Chetla, Calcutta-27



Is a soldier without dying
a lover without sighing.

Biswarup Ganguly
Chowdhuripara, Andul
Howrah.



Gautom Mukherjee
92A, Chittaranjan Avenue,
Calcutta-12

No problem-Let's convince
him first.

Indrojit Sinha
"ARUNALAY"
P.O. Suri
Dist. Birbhum.

Always a silent Lover !

Amit Das
Vill. & P O -Darua,
Dist Midnapore.

He says :— 'Life cannot exist without wife.'

'Bhombol' - rolls everywhere except in Love.

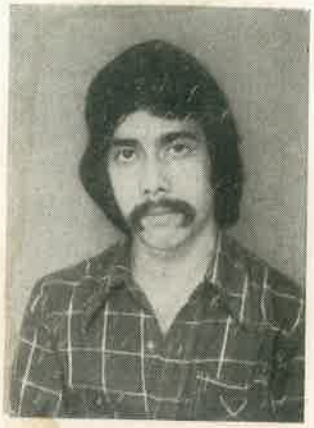
Debotash Dutta
"Basanti Bhawan"
Durgachak
Midnapore.

Alokesh Lahiri
7G, Cornfield Road.
Calcutta-19.

Nature calls him at least 24 times a day.

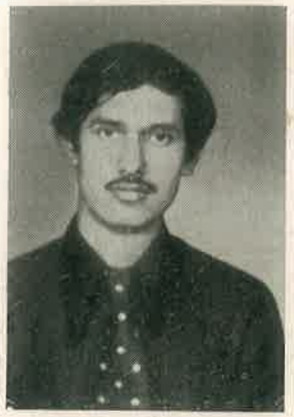
Partha Ghosh
I/3, Raik's House
Govt Estate,
P.O. & Dist. Hooghly.

Our 'Complex' finds complicacy in all simple works.



Soumendranath Bhowmick
Q/6, Sahapur Govt.
Housing Estate
Calcutta-700 038

Compaction due to overburden hair-pressure.



Kabir Das Gupta
27/2, Gopal Lal Chowdhury
Lane, Howrah-3

The martyr of 'Swadeshi Movement.'

Our peculiar dressed giant is really a terror for any mess-committee.

Nikhil Ranjan Chatterjee
CF-63, Salt-Lake City
Calcutta-64

Anup Mukherjee
C/o. Mrs. Malati Mukherjee
S.E. Rly. Health Centre
P.O. Tharsuguda.
Dist. Sambalpur, Orissa.

Line of demarcation between Nepalese & Bengalese.

Indrajit Sen Gupta
Block B-21, Flat-7
Kalindi Housing Estate
Kaliadaha Calcutta-89

The cool 'Ranging Rod' Standing erect in the Survey-field.

Raghunath Sarkar
No. 1. M. G. Road.
(Near pirpukur)
Burdwan-713 101.

The ticket less traveller from Howrah to Burdwan heavy penalty awaits you.

Subir Bhowmick
86/1, Debi Pukur Road,
Hind Motor, Hooghly,
Pin-712 233

Better known as 'Boss'

Milan Ganguly
530, Dum-Dum park
Tank No.-3
Calcutta-55

The Father of Civil Engineering.

Tapan Mitra
49/1, Sardar Shankar Road.
Calcutta-700 029

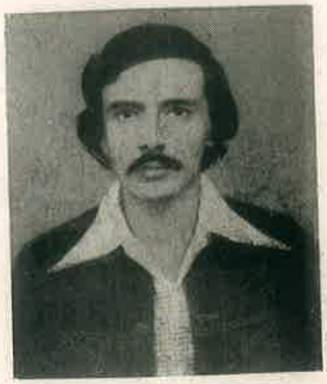
Last but not the least, an exception to the common phenomenon.

Subhasish Bhattacharya
261, Jessore Road, Patipukur,
Calcutta-700 089

Jack of all trades but master of none

Shiva Ratna Raj Bahak
20/268, Gyane Swore
Kathmandu, Nepal.

B.E. College Model School attracts him more than B. E. College



Hari Krishna Poudel
Paras Nagar, Chitwan,
Narayanee Zone, Nepal.

The 'King of Nepal' has not found any suitable queen.

Alas ! The prince of Nepal finds no charm in Nepali girls.

Bhairab Basnet
Ithari Gaisar, Sunsari, K.Z.
Nepal.

V. M. Jnawali
Balkot, Arghakhanchi,
Lumboni Zone, West Nepal.

An exiled dacoit of Nepal.

T. B. Budhathoky
Budhathoky Traders
Laxmi Rice Mill
Ghorahi Bazar, Dang
(Rapti-Zone) Nepal.

Do not think him as a professor

Chinmoy Chowdhury
42, Nandan Kanan Belgharia
Calcutta-56.

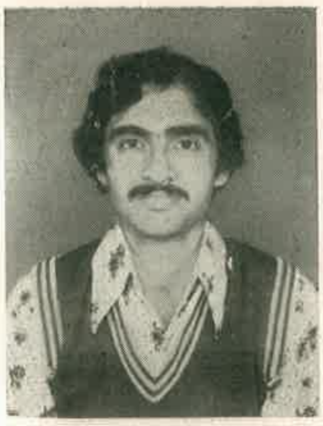
If you are Seventeen Love our 'Sweet Sixteen'

Tamal Bhattacharya
364, Dum-Dum Park
Calcutta-55,

He thinks himself as a 'Lady-Killer' but every lady Kills him.

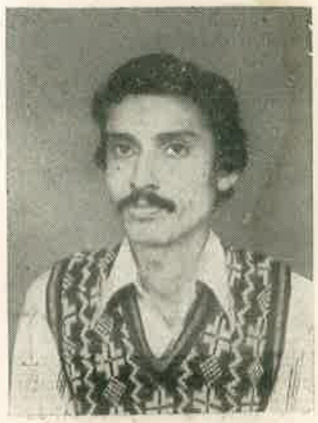
Our bold-headed Chief Designer.

Sushanta Kr. Bhattacharya
3/2, Adyonath Saha Road,
Calcutta-700 048.



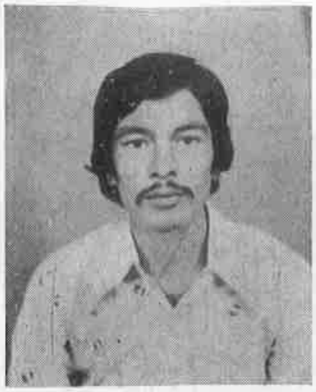
Deb Kumar Banerjee
21, Nawab Abdul Latif Street,
Belgharia,
Calcutta-700 056.

His voice reminds us that the spring is near-by.



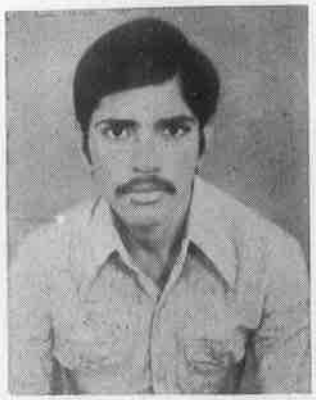
Sujan Bhattacharya
P-115 Lake Town
Block-B
Calcutta-700 089

Only wrestler to represent India in the next olympic.



Chandi Prasad Khanra
63/14, Brindaban Mullick Lane, Howrah-711 101

'Carry on Sir' —is his only slogan.

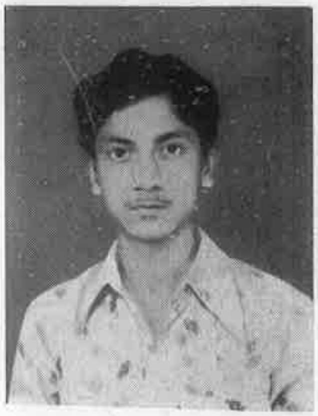


Biswajit Chongdar
306, Circular Road, Shibpur, Howrah-2

Tries to bridge the gap between playing bridge and designing bridges.

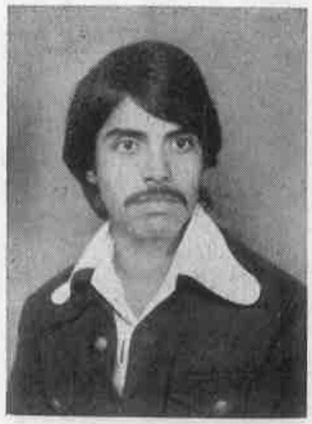
Always keeps himself away from the laboratory instruments.

Indra Kumar Mishra
V. & P.-Jilathi, Dist :- Saptari, Rajbiraj Nepal.



Paramanu Bhowmick
19/2H, Ultadanga Road, Calcutta-700 004

Still keeping her position as 'Miss-Civil'



Rambahadur Saha
Rajbiraj-1 Dist-Saptary, Nepal

One of our professors told him 'Great Bahadur'

SOCCE REPORTS
1980-'81

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'SOCIETY OF CIVIL ENGINEERS'

FOR THE SESSION 1980-81.

—: o :—

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Vice President	:	Shri Sanjib Chakraborty	(5th Year)
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Asst. Tour Secretary	:	,, Santanu Lahiri	(1st Year)
Jt. Literarary Secretaary	:	,, Sujan Bhattacharya	(5th Year)
		,, Atanu Datta	(3rd Year)

Report from the General Secretary—

It has always been our cherished dream to renew and where necessary, to establish the rapport and deep sense of attachment that binds us together. The civil engineer is just one of the means of communication that helps us to bridge the gap. Over the years the publication of 'The Civil Engineer' has been synonymous with the Reunion celebration and this year, too, we have been able to maintain the tradition. This magazine provides an ideal forum for free exchange of ideas and also of recent developments in the field of civil engineering.

In view of the stiff competition that confronts a fresh engineer, it will be not far from truth to say that apart from academic and extra-curricular activities in the college, the students ought to be familiar with the professional world existing outside the college campus. Our society has remained conscious in its endeavour to instill the sense of professionalism within the students to enable them to cope with the numerous difficulties once they graduate.

The civil engineering students have renewed, under the auspices of SOCCE, their membership of the students' chapter of the Institution of Engineers (India). This is not only benificial to the students but also helps to play a vital role in maintaining a cordial relationship with the pioneer organisation of engineers.

I take the privilege of extending our sincere gratitude to Dr. S. P. Brahma, the president of the Society of Civil Engineers, and all members of the staff for their efforts and valuable advice for all activities regarding the society. I would also like to record our indebtness to all ex-students and patrons for their co-operation and assistance, of-course not forgetting our Magazine Secretary, for successfully publishing this Annual Technical Publication.

Last but not least, I extend the sincere thanks on behalf of SOCCE in presenting you a copy of this Annual and hope that our society will stamp its excellence both in and out of college by receiving your good wishes in future.

ABUL BASAR SARKAR.

REPORT FROM THE MODEL SECRETARIES

—: o :—

Model is nothing but the representation of any existing or proposed project in reduced scale. The Society of Civil Engineers always encourage modelling of different kinds and of different thoughts in Civil Engineering and its allied fields. In spite of huge time to be devoted, besides our academic works, every year the members take the opportunity to construct models and to demonstrate it before the audience in the Re - Union Celebration. This year is no exception. Like the past years we are going to represent a few models of something new kind which I hope will be cherished by everybody.

Hereby I also take the opportunity to thank all our revered Professors, our work-shop experts, our colleagues and our well-wishers, who always extended their hearty co-operation in this respect.

Subhasish Bhattacharyya (*5th yr.*)
Ashim Chakravorty (*3rd yr.*)
Ashis Bose (*2nd yr.*)

REPORT FROM THE GAMES SECRETARIES

We feel overwhelmed by the sense of humility to have the opportunity to outline a brief report of the games section of the 'Society of Civil Engineers.'

Since its establishment SOCCE has been arranging the competitions on the games which till the other day was not entertained by B. E. C. Athletic Club.

This year, we have arranged our 'Auction Bridge' and Inter Hostel Table Tennis Tournaments. We hope the 'Society' in future will be in a position to conduct other tournaments.

We express our debt of gratitude and sincere thanks to the students of Civil Engineering Department and those of other branches, who co-operated with us in various ways and their consistence help and guidance to make the above tournaments a success.

We hope that the future students of our department will be more enthusiastic regarding games and will look forward to better activities.

RANJAN PALIT (*5th yr.*)
PRANESH CH. DEBNATH (*3rd yr.*)
SOUMITRA MAITY (*2nd yr.*)

REPORT FROM THE MAGAZINE SECRETARIES

—: o :—

We are glad to announce that in keeping with the nobel tradition of Civil Engineering Society, we are again able to publish our 24th issue of the Annual Technical Journal "THE CIVIL ENGINEER".

To bring out such a volume of any journal in these days is not quite easy. Cost of paper which posed a big difficulty last year continues to persist, printing cost and the other overhead expenses have gone up. The hurdles in our way were thus big. But due to ample support rendered by our respective professors, colleagues, advertisers and patrons we have overcome the difficulties. It is a matter of great triumph, joy & pride that we have been able to bring out this present volume within a few positive working days.

We take this opportunity to express our deep gratitude to all the members of the staff, contributors and advertisers for their active co-operation. Eventually, let the magnanimity of our patrons allow us to believe that this publication remains a testimony of its own value.

Rupak Sarkar (*5th yr.*)
V. Ravi (*3rd yr.*)

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We would neglect our duties if we do not mention the names of the following students without whose untiring efforts, the publication of the journal, in such a few positive working days would not have been possible :

Pranab Talukdar
Anup Mukherjee
Biswajit Chatterjee
Sujit Mukherjee
Biswajit Chongdar
Subir Kr. Garai

ERRATA

On	*Page*	*No.*	*16*	*1st*	*Row*	*1st*	*Line*	*Read Integral Sign. in place of* Σ
,,	,,	,,	*44*	*2nd*	,,	*23rd*	,,	,, *dMc* ,, ,, ,, *dM.*
,,	,,	,,	*45*	,,	,,	*8th*	,,	,, *symmetrical in place of dymmetrical*
,,	,,	,,	*56*	,,	,,	*3rd*	,,	,, *service* ,, ,, ,, *servicc*

on the report of magazine secretaries, please read 'noble' in place of 'nobel' in the first line.

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Readers are earnestly requested to persuade their colleagues and Management to release an impressive advertisement in all the issues of the journal on a regular basis.

The circulation has increased. Cost of paper, printing administration charges and other overhead expenses have also gone up, while the advertising revenue has gone down considerably.

Your personal interest and active co-operation will be of immense help to bring out journal in time and to be of greater service to the Civil Engineering profession.

We are sure that you would not hesitate to do your best and hence this special appeal.