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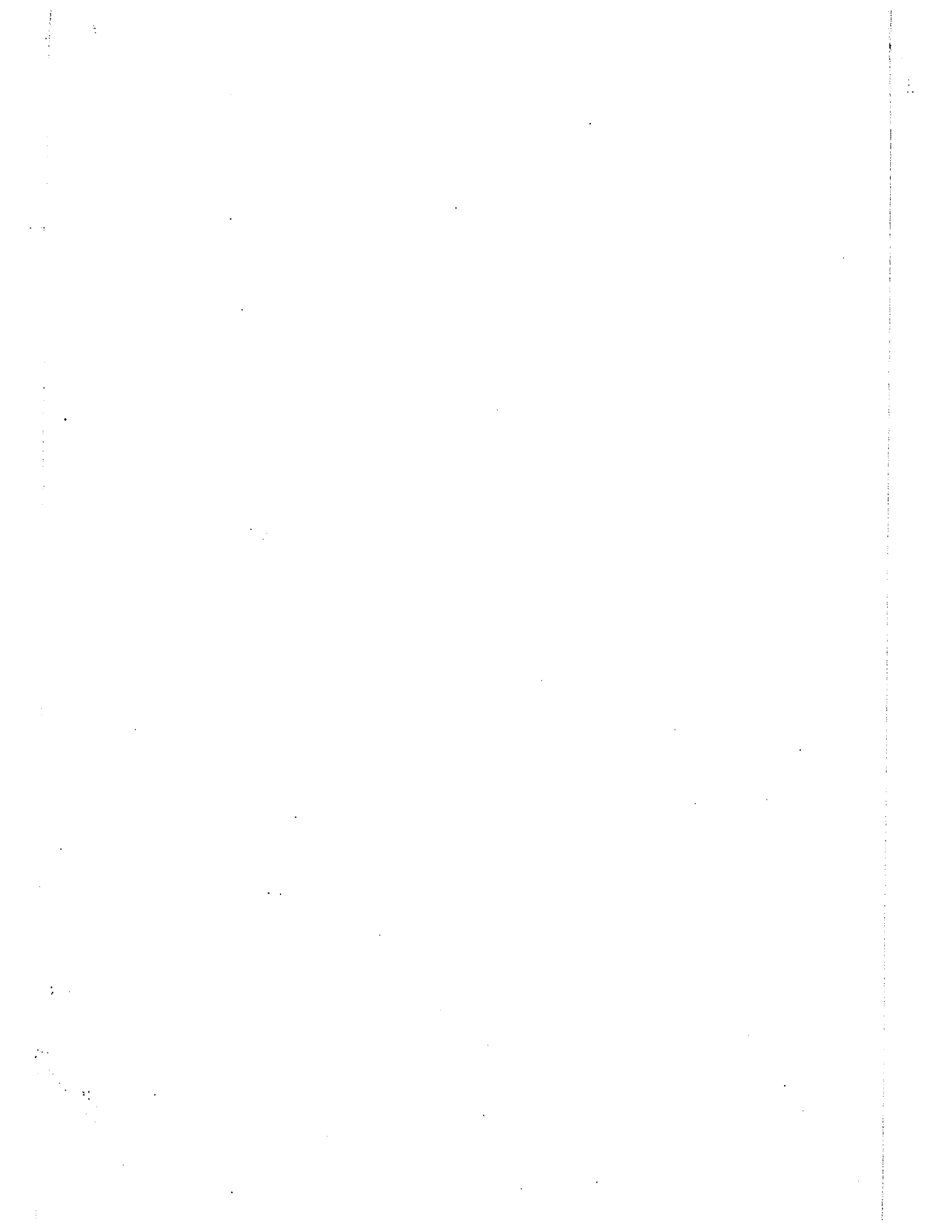
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SHORE - RESHORE CONSTRUCTION SCHEDULING ANALYSIS COMPUTER  
PROGRAM

by

Ali Muscati

A thesis  
submitted to the University of Ottawa  
in partial fulfillment of the  
requirements for the degree of  
Master of Engineering  
in  
Civil Engineering

Department of Civil Engineering  
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CHAPTER 1  
INTRODUCTION AND PURPOSE

In the construction of multifloor reinforced concrete flat slab buildings, the freshly cast slab is usually supported on shores. Shores and reshores are in turn supported on previously cast slabs. The construction loads, transferred by the shores and reshores to these recently cast-partially cured supporting slabs, may appreciably exceed the design loads under service condition or even the strength capacities of these slabs. Such construction loads on the slabs, shores, and reshores depend on the construction schedule and must be calculated.

Fig. 1-1 shows an example of a typical construction cycle which consists of two alternative operations. These operations which control the loads supported on the slabs are :

1. Operation B : Casting of a new slab ,
2. Operation A : Stripping the lowest levels of shores, and  
it may involve placing reshores.

A simplified method to determine the distribution of construction loads for any system of shoring was developed by Grundy and Kabaila (1963)<sup>1</sup>, and extended by Agarwal and Gardner (1974)<sup>2</sup>, and finally presented as a design method by Gardner (1979)<sup>3</sup>.

Gardner (1979)<sup>3</sup> calculated the construction loads on slabs and shores for a two shores plus two reshores system as shown in Fig. 1-1. It is assumed that all slabs have equal stiffness and that both shores and reshores are infinitely stiff.

In operations 1B through 2B (see Fig. 1-1), the loads are carried by the formwork and transferred to a rigid subgrade leaving no loads on the slabs, the loads can be simply calculated by statics. By removing the shores under the first slab in Operation 3A, the load of 2D will be transformed to the upper two slabs which deflect to take the load. The load on the reshores is zero after installing the reshores. After casting the third slab in Operation 3B, its weight will be transmitted to grade by the shoring system. Operations 4A and 4B are similar to Operations 3A and 3B. In Operation 5A the lowest level of shores is removed transferring its load of 1.5D to the upper two slabs which deflect to take the loads while the removal of the lowest reshores level allows the lower two slabs to rebound and take only their own weight of 1.0D.

For a typical construction schedule rising at a rate of one floor per week and using a two levels of shores plus two levels of reshores system, operation 5B involves casting slab # 5, shores or reshores are in position under slab # 2 (21 days old), 3 (14 days), 4 (7 days), and 5 (0 days). The load of five slabs plus shores and reshores weight will be

distributed between the lowest four floors (as shown in Fig. 1-1)

In operation 6A, 5 days later, the shores under slab # 4 will be stripped and replaced by the reshores of slab # 2, the loads will be distributed between slabs # 5 (5 days old), 4 (12 days), 3 (19 days), 2 (26 days).

By equilibrium the distribution of loads on the shoring system can be calculated.

Some of the calculations shown in Fig. 1-1 are summarized in Table 1-1 showing the imposed load ratios at different ages for each slab. It can be noticed that the imposed load ratio varies with age for the same slab, for example the fourth slab carries loads of .75D, 1.0D, 1.5D, and a maximum of 1.75D at ages of 1A, 1B, 2A, and 2B cycles after casting respectively.

To meet the requirement of any building design code the loads determined in Table 1-1 must be factored to be converted into design ultimate loads. The following assumptions are suggested by Agarwal and Gardner (1974)<sup>2</sup> :

1. It is proposed to use a construction load factor of 1.4 which is the Dead Load Factor according to ACI 318-83 CODE<sup>(4)</sup>.
2. The formwork and reshores are each assumed to be 10% of the slab weight.

3. The errors in the theory, by assuming an invariant modulus of elasticity, are approximately 10%.
4. A factored construction live load  $D/N$ , where  $N$  is the total number of supports which is equal to shores plus reshores, is also included to allow for a construction live load of 2400 N/SQM (50 PSF) after Hurd (1977)<sup>5</sup>.

So,

$$U \text{ construction} = \underset{(a)}{1.1} \times \underset{(b)}{1.1} \times \underset{(c)}{1.4} \times \underset{(d)}{LR} \times D + D/N \quad \dots 1-1a$$

Where :

- U = ultimate load ,  
 D = dead load ,  
 (a) = error in theory ,  
 (b) = weight of formwork ,  
 (c) = load factor, and ,  
 (d) = calculated load ratio. (2)

In equation 1-1a, the unfactored construction live load is assumed to be equal to 'D/1.7' ,where Live Load Factor is equal to 1.7 according to ACI 318-83 Code.

Equation 1-1a can be generalized in the following form :

$$U \text{ construction} = \underset{(a)}{(1.1 \times FW \times FD \times LR + FL \times CLR / N)} \times D \quad \dots 1-1b$$

Where :

FW = 1 + the ratio of formwork weight to  
the dead load ,

FD = Dead Load Factor

= 1.4 , according to ACI Code

= 1.25, according to CSA Code<sup>(6)</sup> ,

FL = Live Load Factor

= 1.7 , according to ACI Code

= 1.5 , according to CSA Code ,

CLR = construction live load / dead load .

Table 1-2 summarizes the design ultimate construction loads calculated for the two-shore plus two-reshore system by applying the ACI and CSA load factors. Table 1-2A summarizes the maximum values of design ultimate construction load and the numbers of slabs carrying them.

The strength capacity of any concrete slab depends on the design ultimate strength, age, curing temperature, and the critical mode of behavior of the slab : flexural, bond, or shear, all of which must be considered in the design of any construction cycle.

Table 1-3 shows the design ultimate load capacities for slabs designed for various live load-dead load ratios in terms of multiples of dead load and calculated for ACI and CSA codes by using equation 1-2 :

$$\begin{aligned}
 U \text{ design} &= FD \times D + FL \times L \\
 &= D \times ( FD + FL \times LLR ) \quad \dots\dots\dots 1-2
 \end{aligned}$$

where :

L = design live load , and

LLR = live load-dead load ratio .

The limiting criterion of flat slab failure is considered, in this method, to be the punching shear strength. The relationship between the shear strength and the compressive strength for the same member is :

$$V_{ct} = \text{constant} \times ( f_{ct} )^P \quad \dots\dots\dots 1-3$$

where :

$V_{ct}$  = shear strength at age t,

$f_{ct}$  = compressive strength at age t, and

P = Constant to be determined. Further discussion regarding the value of 'P' is explained in chapter 2.

Using the data of Gardner and Sau (1984)<sup>7,8</sup> for type 10 (Ordinary Portland Cement) and type 30 (High Early Strength Portland Cement) cements, which are listed in Table 1-4, the available ultimate load capacity can be predicted at any age as:

$$( U \text{ available} )_t = U \text{ design} \times ( f_{ct} / f_{c28} )^P \quad \dots\dots\dots 1-4$$

where :

(U available)<sub>t</sub> = ultimate load capacity available at

age  $t$ ,  
 $U$  design = calculated by using equation 1-2,  
 $f_{ct}$  = concrete compressive strength at  
age  $t$ , and,  
 $f_{c28}$  = concrete compressive strength at  
28-day age.

If the value of  $(U \text{ available})_t$  is larger than the critical value of  $(U \text{ construction})$ , the specific shoring system is adequate, otherwise it is not safe.

From Fig. 1-1 it can be easily observed that the maximum unfactored load experienced by the shores is equal to no. of shores times the dead load and by the reshores is equal to the dead load.

The aim of this paper is to write a computer program on a micro-computer to analyze shore - reshore construction scheduling. Necessary background studies on the following areas are required :

1. Investigate and determine a relationship between concrete shear strength and compressive strength.
2. Develop a numerical method to determine the maturity of concrete at any age based on the available experimental results.

CHAPTER 2

SHEAR STRENGTH CAPACITY OF REINFORCED CONCRETE MEMBERS

The effects of construction loads on concrete structures in which the upper floors are shored from the lower floors are limited by three criteria. Those are the flexural strength, deflection, and shear and bond strengths.

Grundy and Kabaila (1963)<sup>1</sup> concluded that the flexural strength may not be the critical factor. Deflection should be limited, as for stresses under working loads with reductions appropriate to the age of the concrete. Shear and bond strengths are critical and the structure should be designed for maximum construction loads derived by elastic consideration, as far as shear and bond are concerned.

If deflection is the governing criterion, the development of the modulus of elasticity with age should be the governing criterion, but the determination of long-term deflection of reinforced concrete members, due to high early-age loads, is not a well researched or easily calculated criterion.

Equation 2-1 is used in the ACI 318-83 to predict the nominal shear strength provided by concrete in beams.

$$V_C = (1.9 \text{ SQR } f_C' + 2500 P_W V_U d/M_U) b_W d$$

but not greater than  $3.5 \text{ SQR } (f_C') b_W d$  ..... 2-1

where :

$V_C$  = nominal shear strength provided by concrete ,  
 $f_C'$  = specified compressive strength of concrete ,  
 $P_W$  = web reinforcement ratio ,  
 $V_u$  = factored shear force at section ,  
 $d$  = beam depth to centroid of reinforcing steel ,  
 $M_u$  = factored moment at section , and  
 $b_W$  = web width.

Zsutty (1968)<sup>9</sup> plotted equation 2-1 and test results from different references, as shown in Fig 2-1, and concluded that equation 2-1 shows a poor correlation with test results and does not give a good prediction for some low values of the cracking shear strength occurring for low values of  $(P_W V_u d/M_u/SQR f_C')$  . He had applied the combined technique of dimensional and statistical regression analysis on the same data and derived the following empirical formula for beams with  $a/d$  above 2.5 :

$$V_C = k ( f_C' P_W d/a )^{0.333} \quad \dots\dots\dots 2-2$$

where  $a = M_u/V_u$

The above formula is remarkably different from the ACI formula ( equation 2-1 ).

A similar formula for beams was developed by Placas, and Regan (1971)<sup>10</sup> as :

$$v_c = 8 (100 A_s f_c' / b_w d)^{0.333}$$

but not greater than  $12 (f_c')^{0.333}$  ..... 2-3

where  $A_s$  = reinforcing steel area.

From the above mentioned three equations, it can be concluded that the relationship between the shear strength and the compressive strength is as follows:

- A. Cube root relationship :  $v_c = \text{constant} \times (f_c)^{0.333}$ ,  
 and B. Square root relationship :  $v_c = \text{constant} \times (f_c)^{0.5}$ .

The cube root relationship was also used by Batchelor and Kwun (1981)<sup>11</sup>, and by Mphonde and Frantz (1984)<sup>12</sup>. It was adopted by Regan (1981)<sup>13</sup> for calculation of punching shear in flat slab design.

More experimental studies were done by Van der Berg (1962)<sup>14</sup>, and Hanson (1958)<sup>15</sup> which concluded that as the concrete compressive strength increases, the shear strength increases at a slower rate than the (SQR  $f_c$ ) proposed by the ACI Code.

Gardner and Poon (1976)<sup>16</sup> repeated experimental studies on concrete cylinders and they concluded that the bond and tensile strengths are proportional to the 0.8 power of the cylinder compressive strength at the appropriate age. As shear strength is governed by the tensile strength, Gardner (1979)<sup>3</sup> assumed that the shear strength is also proportional to the 0.8 power of the cylinder compressive strength.

- C. 0.8 power relationship :  $v_c = \text{constant} \times (f_c)^{0.8}$

Table 2-1. shows the relation of various concrete member strengths to compressive strength and it can be concluded that the three relationships A, B, and C are the governing criterion for any value of flexural steel ratio.

Gardner (1979)<sup>3</sup> used the 0.8-power relationship as the governing criterion. In this paper, it will be up to the computer program user to choose one of the followings values :

- A. The 0.333 power relationship, least conservative.
- b. The 0.5 power relationship .
- C. The 0.8 power relationship .
- d. The 1.0 power relationship, most conservative.

### CHAPTER 3

#### THE MATURITY OF CONCRETE

Concrete strength develops with age as a result of the chemical reaction between water and cement. Such development depends on how much of the cement has reacted with water, which is called the degree of hydration. The degree of hydration depends on three factors :

1. Age.
2. Curing regime.
3. Temperature history.

In fast construction schedules, those three factors are important to achieve the schedule and maintain its safety. This is most critical during winter construction, which involves a low rate of hydration and a slow strength development due to the low temperature, leaving the contractor with a long stripping schedule or using expensive artificial heating.

Klieger (1958)<sup>17</sup> studied the influence of temperature during mixing, placing, and curing on the development of concrete compressive strength. His results, for ASTM type I and III cement concretes, are summarized in Table 3-1 and shown in Figs. 3-1 to 3-4.

A recent study on concrete compressive strength development has been done by Gardner and Sau (1984)<sup>7,8</sup>. Their results, for

CSA types 10 and 30 cement concretes, are summarized in Table 1-4 and shown in Figs. 3-5 to 3-14.

From Figs. 3-15 to 3-24, a significant difference between the two sets of experimental results can be observed. Gardner and Sau (1984)<sup>7</sup> concluded that the quality of cement had been improved over the period of 25 years between 1958 to 1984. The chemical composition and the average strength of CSA type 10 portland cement is roughly equal to the appropriate averages of the chemical composition and the compressive strength of ASTM type I and type III cements used by Klieger in his study.

The maturity method has been proposed to fill the need for a numerical method combining the effects of temperature and time on the concrete strength development.

The word ' Maturity ' was used for the first time by Saul (1951)<sup>19</sup>, to define the combined effects of age and temperature above some datum. The datum, for ordinary temperature curing, was suggested to be -10.5 degree Celsius (13 degree Fahrenheit) recognizing that the hardened concrete can continue to gain strength at temperatures below the freezing point of water. Saul stated :

' Concrete of the same mix at the same maturity (in temperature-time) has approximately the same strength whatever combination of temperature and time go to make up that maturity. '

So maturity can be expressed in a mathematical equation as :

$$M = \int (T - T_0) dt \quad \dots\dots\dots 3-1$$

where :

M = maturity,

T = temperature of the concrete,

$T_0$  = the datum temperature, and

t = age of concrete.

A differential equation to describe the development of concrete strength relative to the limiting strength at infinite age, was proposed by Bernhardt (1956)<sup>20</sup> :

$$d(S/S_u) / dt = K_t (1 - S/S_u)^2 \quad \dots\dots\dots 3-2$$

where :

S = compressive strength, MPa,

$S_u$  = limiting compressive strength at infinite age, MPa,

$K_t$  = value of the rate constant at a specific temperature, 1/day, and

t = age, days.

Integrating equation 3-2 gives :

$$1 / (1 - S/S_u) = K_t t + C \quad \dots\dots\dots 3-3$$

where C is a constant .

The constant C can be evaluated by applying the boundary condition of  $S = 0$  at  $t = t_0$  and obtain the following :

$$S/S_u = K_t (t - t_0) / (1 + K_t (t - t_0)) \quad \dots\dots\dots 3-4$$

where  $t_0$  = age when strength development is assumed to begin (days).

Equation 3-4 is plotted in Fig. 3-25. It represents a hyperbolic curve with a slope equal to ' $K_t$ ' at age of ' $t_0$ ' and is asymptotic to unity at infinite age.

It is important to point out that equation 3-4 is valid only for isothermal conditions when concrete temperature is constant, and that ' $K_t$ ' is a function of the curing temperature.

A similar hyperbolic curve, but without the ' $t_0$ ' term, was proposed by Goral(1956)<sup>22</sup> and adopted by the American Concrete Institute, Committee 209 (23). The committee recommended two equations to predict concrete compressive strength at any age:

$$S = t / (a + B t) S_{28} \quad \dots\dots\dots 3-5$$

$$\text{and, } S = t / (a/B + t) S_u \quad \dots\dots\dots 3-6$$

where :

a and B = constants,

a/B = age of concrete in days when one half of ' $S_u$ ' is reached,

$S_{28}$  = 28-day compressive strength, in MPa.

Committee 209 gave recommended values of the constants a, B, and a/B. Those values are listed in Table 3-2 and, valid only for a curing temperature of  $(23 \pm 1.7)$  degree Celsius and relative humidities above 95%.

Copeland and Kantro (1964)<sup>25</sup> assumed that at early ages there is no effect of hydration on the particle reaction which means that at early ages the W/C ratio has no effect on the rate constant ' $K_t$ ' value. Knudsen (1980)<sup>24</sup> confirmed this assumption for a W/C ratio as low as 0.4.

Geiker and Knudsen (1982)<sup>26</sup>, based on results of testing cement paste, concluded that ' $t_0$ ' increases with the increase in W/C ratio. However Carino (1981)<sup>27</sup>, based on mortar testing, concluded that ' $t_0$ ' is independent of the W/C.

Carino (1984)<sup>21</sup> demonstrated the application of the maturity method to analyze experimental results of the compressive strength of mortar and concrete blocks using a linear regression analysis to evaluate the parameters ' $S_u$ ', ' $K_t$ ', and ' $t_0$ '.

Initially Carino evaluated the limiting strength ' $S_u$ ', by using the approach of Knudsen (1980)<sup>24</sup>, assuming that ' $t$ ' is approximately equal to  $(t-t_0)$  at the later ages. Hence, equation 3-4 can be reordered as :

$$1/S = 1/S_u + (1/(K_t S_u))(1/t) \quad \dots\dots\dots 3-7$$

The relationship between  $1/S$  and  $1/t$  is a straight line as shown in Fig. 3-26.

Table 3-3 summarizes the calculated results of ' $S_u$ ' by applying equation 3-7 on Gardner and Sau's data and the one-year strength experimental results, in section A of Table 3-3, it

can be observed that ' $S_u$ ' calculated results are generally lower than the one-year experimental results, keeping in mind that data at earlier ages can not be used due to the approximation in equation 3-7. In section B the ' $S_u$ ' calculated are generally higher than the one-year experimental results, these results are based on regression analysis of three points data (90, 180, and 360 days only) and are not very dependable. However the differences are negligible.

By substituting the recommended values of  $a/B$  (Table 3-2) in equation 3-6, it is clear that the ACI Committee 209 use the approximation ' $S_u$ ' equal to the one-year strength.

Having assumed the values of ' $S_u$ ' equal to one-year strength equation 3-4 can be written as :

$$S / (S_u - S) = -K_t t_0 + K_t t \quad \dots\dots\dots 3-8$$

Fig. 3-27 shows a straight line relationship between  $S/(S_u - S)$  and  $t$ . The results of applying equation 3-8 on Gardner and Sau's, and Klieger's experimental data are summarized in Table 3-4. They show a serious imperfections, ' $t_0$ ' values are too large or negative in most of the cases. That is probably due to insufficient data at the very early ages and the wide range of ages, from 3 days to 1 year.

In order to improve the results, all the data were plotted and strengths for ages of 0.5, 1.0, 1.5, 2.0, 2.5, and 3.0 days were interpolated from the plotted curves. Adding to them the available experimental data up to 14 days and the (0,0)

origin, better results were found for ' $K_t$ ' and ' $t_o$ '. Once again, much better results can be obtained by applying equation 3-8 on the 0-7 days region, which is the most critical region for the construction schedule design. The final results of ' $K_t$ ' and ' $t_o$ ' are summarized in Table 3-5. Figs. 3-28 to 3-40 show plots of experimental and calculated curves. It can be observed that the appropriate curves are mostly close enough in the 0-7 days region. However ' $t_o$ ' is still negative for some of the cases but very close to zero, this was improved by inserting the origin of (0,0) with the data.

From the results of ' $t_o$ ' in Table 3-5, it is quite clear that these results do not agree with Carino<sup>27</sup> conclusion on mortar and Geiker and Knudsen conclusion on cement paste. Although, ' $t_o$ ' values change with the W/C ratio, but they are still very close in most of the cases.

In Figs 3-41 to 3-43, another interesting aspect can be found, that the curves recommended by ACI Committee for 22 degree Celsius are very close to the calculated ones by using equation 3-4 and using Klieger's, and Gardner and Sau's experimental results.

As was mentioned before, equation 3-4 is valid only for isothermal conditions. For variable temperature condition, the Arrhenius equation was proposed by Carino<sup>21</sup> to relate ' $K_t$ ' and the curing temperature as follows :

$$K(T) = B \exp(-E/(R T_k)) \quad \dots\dots\dots 3-9$$

where :

- $K(T)$  = function representing the variation of the  
rate constant with temperature, 1/days,  
 $B$  = constant, 1/days,  
 $E$  = apparent activation energy , KJ/mol,  
 $R$  = gas constant = 8.3144 J/(k.mol), and  
 $T_k$  = absolute temperature of cement mortar, or  
concrete, K ( $K = C + 273$ ).

Equation 3-9 can be rewritten, by taking the natural logarithm of its both sides, as :

$$\ln K(T) = \ln B - (E/R) (1/T_k) \quad \dots\dots\dots 3-10$$

If this equation is valid, then there should be a linear relationship between  $\ln K(T)$  and the reciprocal of the absolute temperature.

Figs. 3-44 to 3-47 show Klieger's, and Gardner and Sau's results which are not consistent with equation 3-10 and show a better smooth curve fit.

Carino<sup>18</sup> plotted Klieger's results of one-year compressive strength of concrete versus the curing temperature in degree Celsius using type I cement concrete, and his results, working on mortar made by using type III cement and found the straight line relationship as shown in Fig. 3-48. The results used were for concrete and mortar cured at temperatures above the freezing point of water. Once again, Klieger's results, plotted in Figs. 3-49 and 3-50 show a better smooth curve fit

rather than a straight line fit. Results of type I cement concrete can be fitted by two straight lines, with the first line between -3.9 and 10, and the second line between 10 and 50 degree Celsius, as shown in Fig 3-51. However, this is not the case for type III results as shown in Fig. 3-52.

### Conclusion and Recommendations :

The objective of this chapter was to find equations to represent the development of concrete compressive strength which requires the followings :

1. Evaluating the values of ' $S_u$ '.
2. Evaluating ' $t_o$ ', and ' $K_t$ ' values.
3. Develop a numerical relationship between ' $K_t$ ' and concrete curing temperature.
4. Develop a numerical relationship between ' $S_u$ ' and concrete curing temperature.

The first requirement was fulfilled by assuming ' $S_u$ ' is equal to the one-year strength.

The second requirement was also satisfied and reasonable values of ' $K_t$ ' and ' $t_o$ ' were found. However, some values of ' $t_o$ ' were negative but higher than -2.0 days and in most of the cases not less than -1.0 day. In order to avoid this error, it is recommended to measure the compressive strength of concrete at a very early ages like 0.5, 0.75, 1.0, 1.5, 2.0 days, etc, using a sufficient number of cylinders at each age.

Generally, the calculated curves were close to the experimental ones and can be used in the computer program.

The third and fourth requirements were not fulfilled . The experimental results were not consistent with the proposed method. The disadvantage in Klieger's test is that he cast and cured the concrete cylinders up to 28 days at the same temperature (except for the case of  $-3.9^{\circ}\text{C}$ -temperature) , after that he cured all the samples at the room temperature of  $22.8^{\circ}\text{C}$ . Gardner and Sau did not take enough variety of curing temperatures, so it is not possible to draw a conclusion from their results.

In the computer program, the W/C ratio is assumed to be equal to 0.55 which is a conservative case as shown in Figs 3-5 to 3-14. The following equations were used :

A. For type 10 cement concrete :

1. For a curing temperature of 16 degree Celsius and above:

$$S = 33 \times .182 (t + .694) / ( 1 + .182 (t + .694) )$$

2. For a curing temperature of zero degree Celsius and below:

$$S = 25 \times .106 (t - .610) / ( 1 + .106 (t - .610) )$$

3. For a curing temperature between zero and 16 degree

Celsius, values of S can be determined by linear interpolation of the above two equations and by applying equation 3-4 once again.

B. For type 30 cement concrete :

1. For a curing temperature of 22 degree Celsius and above:

$$S = 53 \times .357 (t + .182) / ( 1 + .357 (t + .182) )$$

2. For a curing temperature of zero degree Celsius and below :

$$S = 42 \times .305 (t - .720) / ( 1 + .305 (t - .720) )$$

3. For a curing temperature between zero and 22 degree Celsius, values of S can be determined by linear interpolation of the above two equations and by applying equation 3-4 once again.

Where S is the compressive strength of concrete, in MPa, at any age 't', in days.

Plots of the above described equations are shown in Figs. 3-53 and 3-54.

The interpolation gives approximate results of S. The computer program can be modified later when more experimental data become updated.

## CHAPTER 4

### SHORE - RESHORE CONSTRUCTION SCHEDULING ANALYSIS COMPUTER PROGRAM

The program is written for IBM-Personal Computer in Basic language. The main flow chart is shown in Fig. 4-1. The program is listed in Appendix 1.

It is based on comparing the slab's available ultimate load capacity with the factored applied load and considering the shear strength as the control criterion (for more details refer to chapters 1 and 2).

In order to use this program, it is important to define the terms used in the program.

In fig. 4-2 the procedures for casting slab # 5 is shown and the following criteria can be observed :

1. Cycle A : is the operation of stripping the shores.
2. Cycle B : is the operation of casting a slab.
3. Time of stripping is the period between casting a slab and stripping the forms.
4. Time of casting is the period between casting two successive slabs .
5. Cycle # : is the age of a slab in cycles after casting.

In our example :

Time of stripping = 33 - 28 = 5 days ,

Time of casting = 35 - 28 = 7 days ,

For slab # 3 :

Cycle 2 A : is the operation of preparing for casting slab # 5 (33 days after starting the construction).

Cycle 2 B : is the operation of casting slab # 5 (35 days after starting the construction).

The program gives three alternative methods of analysis as shown below :

1. If the time of casting, the time of stripping, and the type of shoring system are known, method # 1 can be used to determine if the cycle is safe or not. This method is significant to a contractor having a fixed schedule and wanting to check it's safety.
2. If only the type of shoring system is known, method # 2 can be used to determine times of stripping and casting. The computer will give a note if this shoring system is not possible at all.
3. If only times of stripping and casting are known, method # 3 can be used with entering the possible maximum number of shores and reshores can be used, the computer will give all the possible solutions.

#### Program Operating Manual :

The following input data are required to analyses your problem :

- ]. TYPE OF CEMENT TO BE USED:  
 ENTER 10 FOR TYPE 10 .OR  
 ENTER 30 FOR TYPE 30 :
2. CURING TEMPERATURE IN DEGREE CELSIUS -
3. DESIGN CODE USED  
 ENTER CSA OR ACI .
4. LOADS IN KPa  
 LIVE LOAD -  
 DEAD LOAD -  
 CONSTRUCTION LIVE LOAD,  
 (SUGGESTED VALUE - 2.4) -
5. INPUT RATIO OF FORMWORK WEIGHT TO DEAD LOAD:  
 SUGGESTED VALUES :  
 FOR WOOD AND ALUMINIUM FORMS - .1  
 FOR STEEL FORMS - .2  
 RATIO -
6. TOTAL NUMBER OF FLOORS -
7. THIS PROGRAM IS BASED ON THE FOLLOWING RELATIONSHIP :  
 -----  
 SHEAR STRENGTH = CONSTANT\*(COMPRESSIVE STRENGTH)<sup>P</sup>  
 THE SUGGESTED VALUES FOR P ARE :
- |                                  |            |
|----------------------------------|------------|
| 1. ACCORDING TO ZSUTTY           | : P = .333 |
| 2. ACCORDING TO ACI & CSA CODES  | : P = .5   |
| 3. ACCORDING TO GARDNER AND POON | : P = .8   |
| 4. MOST CONSERVATIVE             | : P = 1.0  |
- CHOOSE P VALUE . P -
8. SPECIFIED DESIGN COMPRESSIVE STRENGTH OF CONCRETE.  
 AT 28 DAYS WITH A CURING TEMP. OF 22 C  
 IN MPA
9. ENTER SPECIFIED CONSTRUCTION COMPRESSIVE STRENGTH OF CONCRETE.  
 AT 28 DAYS FOR 0 C CURING TEMPERATURE, IN MPa.  
 OR PRESS <RETURN> TO TAKE THE GIVEN EXPERIMENTAL VALUE

Item 1,3,4,6, and 8 should be the same as the building design specifications. Item 5, and 7 can be chosen from the given suggestions. It is recommended to use 'P=.8' in item # 7.

The best way to explain the procedure is to analyze an example as follows :

1. To start the program ask for SHORE ( LOAD"SHORE").
2. Press F2 (RUN).

3. Turn on the < Caps Lock > .

4. The followings will appear on the screen :

DATA INPUT .  
-----

TYPE OF CEMENT TO BE USED:

ENTER 10 FOR TYPE 10 .OR  
ENTER 30 FOR TYPE 30

5. Start input you data as in the following example :

DATA INPUT :  
-----

TYPE OF CEMENT TO BE USED:

ENTER 10 FOR TYPE 10 .OR  
ENTER 30 FOR TYPE 30 :10

CURING TEMPERATURE IN DEGREE CELSIUS - 5

DESIGN CODE USED :

ENTER CSA OR ACI : ACI

LOADS IN KPa :

LIVE LOAD - 8

DEAD LOAD - 5

CONSTRUCTION LIVE LOAD,

(SUGGESTED VALUE - 2.4) - 2.4

INPUT RATIO OF FORMWORK WEIGHT TO DEAD LOAD:

SUGGESTED VALUES :

FOR WOOD AND ALUMINIUM FORMS - .1  
FOR STEEL FORMS - .2

RATIO - .1

TOTAL NUMBER OF FLOORS - 10

THIS PROGRAM IS BASED ON THE FOLLOWING RELATIONSHIP :

-----  
SHEAR STRENGTH = CONSTANT\*(COMPRESSIVE STRENGTH)<sup>P</sup>

THE SUGGESTED VALUES FOR P ARE :

1. ACCORDING TO ZSUTTY	: P = .333
2. ACCORDING TO ACI & CSA CODES	: P = .5
3. ACCORDING TO GARDNER AND POON	: P = .8
4. MOST CONSERVATIVE	: P = 1.0

CHOOSE P VALUE , P = .8

SPECIFIED DESIGN COMPRESSIVE STRENGTH OF CONCRETE,

AT 28 DAYS WITH A CURING TEMP. OF 22 C ,

IN MPA

- 25

The computer will display the following information and continue to input the data :

THE 28 DAYS-EXPERIMENTAL COMPRESSIVE STRENGTH FOR TYPE 10 ,AT  
5 C CURING TEMPERATURE. ACCORDING TO GARDNER AND SAU EXPERIMENTAL  
RESULTS - 21.45 MPA

FOR CONSTRUCTION PURPOSE, THE MIX STRENGTH SHOULD BE DESIGNED SO THAT 90 % OF THE TEST RESULTS ARE ABOVE THE SPECIFIED DESIGN COMPRESSIVE STRENGTH.

ENTER SPECIFIED CONSTRUCTION COMPRESSIVE STRENGTH OF CONCRETE,  
AT 28 DAYS FOR 5 °C CURING TEMPERATURE, IN MPa.  
OR PRESS <RETURN> TO TAKE THE GIVEN EXPERIMENTAL VALUE -

DO YOU WANT YOUR OUTPUT TO BE PRINTED ON A HARD COPY ?  
ENTER YES OR NO : YES

If you do not want to print your output on a hard copy enter "NO" or press <Return> and the computer will automatically take it as "NO".

After that the computer will display :-

CHOOSE METHOD OF ANALYSIS :

METHOD # 1. INPUT TYPE OF SHORING SYSTEM, CASTING TIME, AND STRIPPING TIME TO FIND OUT IF THE CYCLE IS SAFE OR NOT.

METHOD # 2. INPUT TYPE OF SHORING SYSTEM TO FIND OUT TIME OF CASTING AND TIME OF STRIPPING.

METHOD # 3. INPUT TIME OF CASTING AND TIME OF STRIPPING TO FIND OUT TYPE OF SHORING SYSTEM.

ENTER 1 TO 3 : 2

METHOD # 2 - DATA INPUT :

NO. OF SHORES - 2  
NO. OF RESHORES - 2

After entering the nos. of shores and reshores, the computer will display the results and ask for another try.

TIME OF STRIPPING - 4.78 DAYS  
TIME OF CASTING - 7.49 DAYS

\*\*\*\*\* END OF METHOD # 2 \*\*\*\*\*

DO YOU WANT TO CHANGE YOUR DATA AND TRY AGAIN ?  
ENTER YES OR NO :

Entering "NO" ends the program and entering "YES" or just pressing <Return> gives the following options :

YOU HAVE THE FOLLOWING OPTIONS :

1. CHANGE ALL THE DATA.
2. CHANGE METHOD OF ANALYSIS.
3. SEE THE MAIN DATA AND CHANGE WHAT IS REQUIRED.
4. SEE ALL THE DATA AND CHANGE WHAT IS REQUIRED.

ENTER 1 TO 4 :

If "1" is entered it will start inputting the data all over again. Entering "2" gives the following :

CHOOSE METHOD OF ANALYSIS :

- 
- METHOD # 1. INPUT TYPE OF SHORING SYSTEM, CASTING TIME, AND STRIPPING TIME TO FIND OUT IF THE CYCLE IS SAFE OR NOT.
- METHOD # 2. INPUT TYPE OF SHORING SYSTEM TO FIND OUT TIME OF CASTING AND TIME OF STRIPPING.
- METHOD # 3. INPUT TIME OF CASTING AND TIME OF STRIPPING TO FIND OUT TYPE OF SHORING SYSTEM.

ENTER 1 TO 3 :

Entering "3" will show the main data and ask for corrections as follows :

INPUT DATA TO BE CHANGED :

- 
1. TYPE OF CEMENT TO BE USED : TYPE 10
  2. CURING TEMPERATURE IN DEGREE CELSIUS - 5
  3. SPECIFIED DESIGN COMPRESSIVE STRENGTH OF CONCRETE, AT 28 DAYS WITH A CURING TEMPERATURE OF 22 C - 25 MPa
  4. DESIGN CODE USED : ACI
  5. LOADS IN KPa :  
LIVE LOAD - 8 DEAD LOAD - 5 CONSTRUCTION LIVE LOAD - 2.4
  6. FORMWORK WEIGHT - .1 OF DEAD LOAD.
  7. TOTAL NUMBER OF FLOORS - 10
  8. SHEAR STRENGTH - CONSTANT\*(COMPRESSIVE STRENGTH)\* .8
  9. SPECIFIED CONSTRUCTION COMPRESSIVE STRENGTH OF CONCRETE, AT 28 DAYS FOR 5 C CURING TEMPERATURE - 21.45 MPa

ENTER 1 TO 9 OR PRESS < RETURN > IF NO CHANGES ARE REQUIRED -

Then enter no. of item to be changed and finally press <  
RETURN > if no more changes are required and continue :

DO YOU WANT YOUR OUTPUT TO BE PRINTED ON A HARD COPY ?  
ENTER YES OR NO :

CHOOSE METHOD OF ANALYSIS :

METHOD # 1. INPUT TYPE OF SHORING SYSTEM, CASTING TIME, AND STRIPPING  
TIME TO FIND OUT IF THE CYCLE IS SAFE OR NOT.

METHOD # 2. INPUT TYPE OF SHORING SYSTEM TO FIND OUT TIME OF  
CASTING AND TIME OF STRIPPING.

METHOD # 3. INPUT TIME OF CASTING AND TIME OF STRIPPING TO FIND OUT  
TYPE OF SHORING SYSTEM.

ENTER 1 TO 3 : 1

METHOD # 1 - DATA INPUT :

NO. OF SHORES - 2  
NO. OF RESHORES - 2

TIME OF STRIPPING IN DAYS - 5  
TIME OF CASTING IN DAYS - 7

After entering the above data the output will be displayed :

THE CHOSEN CYCLE IS NOT SAFE.

(ULTIMATE LOAD CAPACITY REQUIRED FOR SLAB # 4 - 3.17 TIMES THE DEAD LOAD)  
> (ULTIMATE LOAD CAPACITY AVAILABLE - 3.11 TIMES THE DEAD LOAD)

THIS HAPPENS AT CYCLE # 2 B

ON SLAB # 4

SLAB BEING CAST IS # 6

PRESS F5 (CONT) TO CONTINUE RUNNING THE PROGRAM.

Press F5 to continue :

OTHER ALTERNATIVES ARE AVAILABLE :

- USE TYPE 30 CEMENT CONCRETE.
- USE A NON-UNIFORM CONSTRUCTION CYCLE.
- CHANGE THE SHORE-RESHORE SCHEDULE EITHER COMPLETELY OR FOR ONE OR MORE CYCLES ONLY.
- USE SUPERPLASTICIZERS TO INCREASE STRENGTH.
- INCREASE THE STRENGTH CAPACITY OF THE SLAB USING COLUMN CAPITALS, DROP PANELS, ETC.
- INCREASE THE 28 DAY SPECIFIED CONCRETE STRENGTH TO GIVE SUFFICIENT NEEDED STRENGTH.

-THE LAST TWO ALTERNATIVES ARE ADDRESSED TO THE ENGINEER ONLY-

PRESS F5 (CONT) TO CONTINUE RUNNING THE PROGRAM.

## INPUT DATA :

- 
1. TYPE OF CEMENT TO BE USED : TYPE 10
  2. CURING TEMPERATURE IN DEGREE CELSIUS - 5
  3. SPECIFIED DESIGN COMPRESSIVE STRENGTH OF CONCRETE, AT 28 DAYS  
WITH A CURING TEMPERATURE OF 22 C - 25 MPa
  4. DESIGN CODE USED : ACI
  5. LOADS IN KPa :  
LIVE LOAD - 8 DEAD LOAD - 5 CONSTRUCTION LIVE LOAD - 2.4
  6. FORMWORK WEIGHT - .1 OF DEAD LOAD.
  7. TOTAL NUMBER OF FLOORS - 10
  8. SHEAR STRENGTH - CONSTANT\*(COMPRESSIVE STRENGTH) .8
  9. SPECIFIED CONSTRUCTION COMPRESSIVE STRENGTH OF CONCRETE,  
AT 28 DAYS FOR 5 C CURING TEMPERATURE - 21.45 MPa
  10. METHOD OF ANALYSIS # - 1
  11. TIME OF STRIPPING - 5 DAYS, TIME OF CASTING - 7 DAYS
  12. 2 LEVEL(S) OF SHORES, 2 LEVEL(S) OF RESHORES
  13. PRINT OUT ON A HARD COPY : YES
  14. TO ESCAPE.

ENTER 1 TO 14 OR PRESS < RETURN > TO CONTINUE -

Make the required correction and continue,

## INPUT DATA :

- 
1. TYPE OF CEMENT TO BE USED : TYPE 10
  2. CURING TEMPERATURE IN DEGREE CELSIUS - 5
  3. SPECIFIED DESIGN COMPRESSIVE STRENGTH OF CONCRETE, AT 28 DAYS  
WITH A CURING TEMPERATURE OF 22 C - 25 MPa
  4. DESIGN CODE USED : ACI
  5. LOADS IN KPa :  
LIVE LOAD - 8 DEAD LOAD - 5 CONSTRUCTION LIVE LOAD - 2.4
  6. FORMWORK WEIGHT - .1 OF DEAD LOAD.
  7. TOTAL NUMBER OF FLOORS - 10
  8. SHEAR STRENGTH - CONSTANT\*(COMPRESSIVE STRENGTH) .8
  9. SPECIFIED CONSTRUCTION COMPRESSIVE STRENGTH OF CONCRETE,  
AT 28 DAYS FOR 5 C CURING TEMPERATURE - 21.45 MPa
  10. METHOD OF ANALYSIS # - 1
  11. TIME OF STRIPPING - 5 DAYS, TIME OF CASTING - 7.5 DAYS
  12. 2 LEVEL(S) OF SHORES, 2 LEVEL(S) OF RESHORES
  13. PRINT OUT ON A HARD COPY : YES
  14. TO ESCAPE.

ENTER 1 TO 14 OR PRESS < RETURN > TO CONTINUE -

LIST 2RUN 3LOAD" 4SAVE" 5CONT 6,"LPT1 7IRON 8TROFFSKEY OSCREEN

13. PRINT OUT ON A HARD COPY : NO
14. TO ESCAPE.

ENTER 1 TO 14 OR PRESS < RETURN > TO CONTINUE -

After pressing < RETURN > the following will be displayed :

THE CHOSEN CYCLE IS SAFE.

\*\*\*\*\* END OF METHOD # 1 \*\*\*\*\*

DO YOU WANT TO CHANGE YOUR DATA AND TRY AGAIN ?  
ENTER YES OR NO :

YOU HAVE THE FOLLOWING OPTIONS :

1. CHANGE ALL THE DATA.
2. CHANGE METHOD OF ANALYSIS.
3. SEE THE MAIN DATA AND CHANGE WHAT IS REQUIRED.
4. SEE ALL THE DATA AND CHANGE WHAT IS REQUIRED.

ENTER 1 TO 4 : 2

CHOOSE METHOD OF ANALYSIS :

METHOD # 1. INPUT TYPE OF SHORING SYSTEM, CASTING TIME, AND STRIPPING TIME TO FIND OUT IF THE CYCLE IS SAFE OR NOT.

METHOD # 2. INPUT TYPE OF SHORING SYSTEM TO FIND OUT TIME OF CASTING AND TIME OF STRIPPING.

METHOD # 3. INPUT TIME OF CASTING AND TIME OF STRIPPING TO FIND OUT TYPE OF SHORING SYSTEM.

ENTER 1 TO 3 : 3

METHOD # 3 - DATA INPUT :

TIME OF STRIPPING IN DAYS - 5  
TIME OF CASTING IN DAYS - 7.5

MAX NO. OF SHORES TO BE USED - 3  
MAX NO. OF RESHORES TO BE USED - 3

After entering the above data, the output will be displayed :

SOLUTION # 1 :

1 LEVEL(S) OF SHORES WITH A MINIMUM OF  
3 LEVEL(S) OF RESHORES

SOLUTION # 2 :

2 LEVEL(S) OF SHORES WITH A MINIMUM OF  
2 LEVEL(S) OF RESHORES

SOLUTION # 3 :

3 LEVEL(S) OF SHORES WITH A MINIMUM OF  
3 LEVEL(S) OF RESHORES

\*\*\*\*\* END OF METHOD # 3 \*\*\*\*\*

DO YOU WANT TO CHANGE YOUR DATA AND TRY AGAIN ?  
ENTER YES OR NO :

YOU HAVE THE FOLLOWING OPTIONS :

1. CHANGE ALL THE DATA.
2. CHANGE METHOD OF ANALYSIS.
3. SEE THE MAIN DATA AND CHANGE WHAT IS REQUIRED.

4. SEE ALL THE DATA AND CHANGE WHAT IS REQUIRED.

ENTER 1 TO 4 : 4

INPUT DATA :

- 
1. TYPE OF CEMENT TO BE USED : TYPE 10
  2. CURING TEMPERATURE IN DEGREE CELSIUS - 5
  3. SPECIFIED DESIGN COMPRESSIVE STRENGTH OF CONCRETE, AT 28 DAYS WITH A CURING TEMPERATURE OF 22 C - 25 MPa
  4. DESIGN CODE USED : ACI
  5. LOADS IN KPa :  
LIVE LOAD - 8 DEAD LOAD - 5 CONSTRUCTION LIVE LOAD - 2.4
  6. FORMWORKS WEIGHT - .1 OF DEAD LOAD.
  7. TOTAL NUMBER OF FLOORS - 10
  8. SHEAR STRENGTH - CONSTANT\*(COMPRESSIVE STRENGTH)\* .8
  9. SPECIFIED CONSTRUCTION COMPRESSIVE STRENGTH OF CONCRETE, AT 28 DAYS FOR 5 C CURING TEMPERATURE - 21.45 MPa
  10. METHOD OF ANALYSIS # - 3
  11. TIME OF STRIPPING - 5 DAYS. TIME OF CASTING - 7.5 DAYS
  12. MAX NO. OF SHORES TO BE USED - 3  
MAX NO. OF RESHORES TO BE USED - 3
  13. PRINT OUT ON A HARD COPY : YES
  14. TO ESCAPE.

ENTER 1 TO 14 OR PRESS < RETURN > TO CONTINUE -

INPUT DATA :

- 
1. TYPE OF CEMENT TO BE USED : TYPE 10
  2. CURING TEMPERATURE IN DEGREE CELSIUS - 5
  3. SPECIFIED DESIGN COMPRESSIVE STRENGTH OF CONCRETE, AT 28 DAYS WITH A CURING TEMPERATURE OF 22 C - 25 MPa
  4. DESIGN CODE USED : ACI
  5. LOADS IN KPa :  
LIVE LOAD - 8 DEAD LOAD - 5 CONSTRUCTION LIVE LOAD - 2.4
  6. FORMWORK WEIGHT - .1 OF DEAD LOAD.
  7. TOTAL NUMBER OF FLOORS - 10
  8. SHEAR STRENGTH - CONSTANT\*(COMPRESSIVE STRENGTH)\* .8
  9. SPECIFIED CONSTRUCTION COMPRESSIVE STRENGTH OF CONCRETE, AT 28 DAYS FOR 5 C CURING TEMPERATURE - 25 MPa
  10. METHOD OF ANALYSIS # - 2
  11. 2 LEVEL(S) OF SHORES, 2 LEVEL(S) OF RESHORES
  13. PRINT OUT ON A HARD COPY : YES
  14. TO ESCAPE.

ENTER 1 TO 14 OR PRESS < RETURN > TO CONTINUE -

TIME OF STRIPPING - 3.5 DAYS  
TIME OF CASTING - 5.06 DAYS

\*\*\*\*\* END OF METHOD # 2 \*\*\*\*\*

DO YOU WANT TO CHANGE YOUR DATA AND TRY AGAIN ?  
ENTER YES OR NO :

6. If you are stuck with something or you made a mistake and do not want to continue press <Ctrl> + <Break> and enter -GOTO 3800- to start again as shown below :

METHOD # 1 - DATA INPUT  
-----

NO. OF SHORES - 2  
NO. OF RESHORES - 3.7

TIME OF STRIPPING IN DAYS -  
Break in 4110  
OK

OK  
GOTO 3800

DO YOU WANT TO CHANGE YOUR DATA AND TRY AGAIN ?  
ENTER YES OR NO :

7. If for any reason the required compressive strength was bigger than the ultimate compressive strength at infinite age a message will be displayed as follows :

METHOD # 2 - DATA INPUT :  
-----

NO. OF SHORES - 2  
NO. OF RESHORES - 2

NO SOLUTION IS POSSIBLE OUT OF THE GIVEN DATA, THE REQUIRED STRENGTH  
( 36.03 MPa ) > THE ULTIMATE STRENGTH ( 32.05 MPa ).

THERE MAY BE A MISTAKE IN THE MAIN INPUT DATA OR IT IS NOT POSSIBLE TO USE  
THIS SHORING SYSTEM

PRESS F5 ( CONT ) TO SEE THE DATA AND TRY AGAIN.

After pressing F5 :

INPUT DATA :  
-----

1. TYPE OF CEMENT TO BE USED : TYPE 10
2. CURING TEMPERATURE IN DEGREE CELSIUS - 5
3. SPECIFIED DESIGN COMPRESSIVE STRENGTH OF CONCRETE, AT 28 DAYS  
WITH A CURING TEMPERATURE OF 22 C - 50 MPa
4. DESIGN CODE USED : ACI
5. LOADS IN KPa :  
LIVE LOAD - 8 DEAD LOAD - 5 CONSTRUCTION LIVE LOAD - 2.4
6. FORMWORK WEIGHT - .1 OF DEAD LOAD.
7. TOTAL NUMBER OF FLOORS - 10
8. SHEAR STRENGTH - CONSTANT\*(COMPRESSIVE STRENGTH)\*.8
9. SPECIFIED CONSTRUCTION COMPRESSIVE STRENGTH OF CONCRETE,  
AT 28 DAYS FOR 5 C CURING TEMPERATURE - 25 MPa
10. METHOD OF ANALYSIS # - 2
11. 2 LEVEL(S) OF SHORES. 2 LEVEL(S) OF RESHORES
13. PRINT OUT ON A HARD COPY : NO
14. TO ESCAPE.

ENTER 1 TO 14 OR PRESS < RETURN > TO CONTINUE -

In the next few pages, the print out of this example is shown.

SHORE - RESHORE CONSTRUCTION SCHEDULING ANALYSIS PROGRAM

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INPUT DATA :

TYPE OF CEMENT TO BE USED: TYPE 10

CURING TEMPERATURE IN DEGREE CELSIUS = 5

SPECIFIED DESIGN COMPRESSIVE STRENGTH OF CONCRETE,  
AT 28 DAYS WITH A CURING TEMPERATURE OF 22 C = 25 MPa

SPECIFIED CONSTRUCTION COMPRESSIVE STRENGTH OF CONCRETE,  
AT 28 DAYS FOR 5 C CURING TEMPERATURE = 21.45 MPa

DESIGN CODE USED : ACI

LOADS IN KPa :

LIVE LOAD = 8  
DEAD LOAD = 5  
CONSTRUCTION LIVE LOAD = 2.4

FORMWORK WEIGHT = .1 OF DEAD LOAD.

TOTAL NUMBER OF FLOORS = 10

THIS ANALYSIS IS BASED ON THE FOLLOWING RELATIONSHIP :

SHEAR STRENGTH = CONSTANT\*(COMPRESSIVE STRENGTH) .8

METHOD # 2 :

2 LEVEL(S) OF SHORES  
2 LEVEL(S) OF RESHORES

TIME OF STRIPPING = 4.78 DAYS  
TIME OF CASTING = 7.49 DAYS

\*\*\*\*\* END OF METHOD # 2 \*\*\*\*\*

METHOD # 1 :

2 LEVEL(S) OF SHORES  
2 LEVEL(S) OF RESHORES

36

TIME OF STRIPPING - 5 DAYS  
TIME OF CASTING - 7 DAYS

THE CHOSEN CYCLE IS NOT SAFE.

(ULTIMATE LOAD CAPACITY REQUIRED FOR SLAB # 4 = 3.17 TIMES THE DEAD LOAD)  
> (ULTIMATE LOAD CAPACITY AVAILABLE = 3.11 TIMES THE DEAD LOAD)  
THIS HAPPENS AT CYCLE # 2 B  
ON SLAB # 4  
SLAB BEING CAST IS # 6

OTHER ALTERNATIVES ARE AVAILABLE :

- \* USE TYPE 30 CEMENT CONCRETE.
  - \* USE A NON-UNIFORM CONSTRUCTION CYCLE.
  - \* CHANGE THE SHORE-RESHORE SCHEDULE EITHER COMPLETELY OR FOR ONE OR MORE CYCLES ONLY.
  - \* USE SUPERPLASTICIZERS TO INCREASE STRENGTH.
  - \* INCREASE THE STRENGTH CAPACITY OF THE SLAB USING COLUMN CAPITALS, DROP PANELS, ETC.
  - \* INCREASE THE 28 DAY SPECIFIED CONCRETE STRENGTH TO GIVE SUFFICIENT NEEDED STRENGTH.
- THE LAST TWO ALTERNATIVES ARE ADDRESSED TO THE ENGINEER ONLY-

\*\*\*\*\* END OF METHOD # 1 \*\*\*\*\*

METHOD # 1 :

2 LEVEL(S) OF SHORES  
2 LEVEL(S) OF RESHORES

TIME OF STRIPPING - 5 DAYS  
TIME OF CASTING - 7.5 DAYS

THE CHOSEN CYCLE IS SAFE.

\*\*\*\*\* END OF METHOD # 1 \*\*\*\*\*

METHOD # 3 :

37

TIME OF STRIPPING - 5 DAYS  
TIME OF CASTING - 7.5 DAYS

MAX NO. OF SHORES TO BE USED - 3  
MAX NO. OF RESHORES TO BE USED - 3

SOLUTION # 1 :

1 LEVEL(S) OF SHORES WITH A MINIMUM OF  
3 LEVEL(S) OF RESHORES

SOLUTION # 2 :

2 LEVEL(S) OF SHORES WITH A MINIMUM OF  
2 LEVEL(S) OF RESHORES

SOLUTION # 3 :

3 LEVEL(S) OF SHORES WITH A MINIMUM OF  
3 LEVEL(S) OF RESHORES

\*\*\*\*\* END OF METHOD # 3 \*\*\*\*\*

SHORE - RESHORE CONSTRUCTION SCHEDULING ANALYSIS PROGRAM

INPUT DATA :

36

TYPE OF CEMENT TO BE USED: TYPE 10

CURING TEMPERATURE IN DEGREE CELSIUS - 5

SPECIFIED DESIGN COMPRESSIVE STRENGTH OF CONCRETE,  
AT 28 DAYS WITH A CURING TEMPERATURE OF 22 C - 25 MPa

SPECIFIED CONSTRUCTION COMPRESSIVE STRENGTH OF CONCRETE,  
AT 28 DAYS FOR 5 C CURING TEMPERATURE - 25 MPa

DESIGN CODE USED : ACI

LOADS IN KPa :

LIVE LOAD - 8  
DEAD LOAD - 5  
CONSTRUCTION LIVE LOAD - 2.4

FORMWORK WEIGHT - .1 OF DEAD LOAD.

TOTAL NUMBER OF FLOORS - 10

THIS ANALYSIS IS BASED ON THE FOLLOWING RELATIONSHIP :

SHEAR STRENGTH = CONSTANT\*(COMPRESSIVE STRENGTH)<sup>.8</sup>

METHOD # 2 :

2 LEVEL(S) OF SHORES  
2 LEVEL(S) OF RESHORES

TIME OF STRIPPING - 3.5 DAYS  
TIME OF CASTING - 5.06 DAYS

\*\*\*\*\* END OF METHOD # 2 \*\*\*\*\*

CHAPTER 5  
DESIGN OF FLAT SLABS FOR SHEAR

The new CSA code(1984)<sup>6</sup> is generally based upon ACI 318-83(4). However, there are many changes from the ACI code. Some of the changes, which effect the shear design, will be discussed in this chapter.

For a typical flat slab designed for a combination of live load and dead load, the following terms and equations are given by the two codes :

1. Load factors :

	CSA	ACI
for dead load	1.25	1.4
for live load	1.5	1.7
So, ultimate load capacity is :		
	$1.25 D + 1.5 L$	$1.4 D + 1.7 L$

where D = dead load, and L = live load

2. The resistance factors :

	CSA	ACI
for concrete	0.6	0.85
for reinforcing bars	0.85	0.85

### 3. Factored shear resistance for non prestressed slabs :

$$\text{CSA : } V_r \geq V_f$$

$$V_r = V_c + V_s$$

$$V_c = .2 (1+2/B_c) q \phi_c \text{SQR}(f_c') b_o d$$

$$< .4 q \phi_c \text{SQR}(f_c') b_o d$$

$$\text{ACI : } V_u \leq \phi_c V_n$$

$$V_n = V_c + V_s$$

$$V_c = .17 (1+2/B_c) \text{SQR}(f_c') b_o d$$

$$< .33 \text{SQR}(f_c') b_o d$$

Where :

$V_r$  = factored shear resistance, newtons

$V_f = V_u$  = factored shear force at section,  
newtons

$V_n$  = nominal shear resistance

$V_c$  = factored shear resistance provided by  
concrete, newtons

$V_s$  = factored shear resistance provided by shear  
reinforcement, newtons

$\phi_c$  = resistance factor for concrete,

$q$  = factor to account for low density concrete  
= 1.0 for normal density concrete

$B_c$  = the ratio of long side to short side of  
concentrated load or reaction area

$b_o$  = the perimeter of the critical section, mm

$d$  = slab depth, mm, and

$f_c'$  = specified compressive strength of concrete,  
MPa.

## 4. Comparison of design codes provisions :

	ACI	CSA
Design ultimate load	$U = (1.4D + 1.7L) / \phi_c$ $= 1.4(1 + 1.214L/D) / .85$ $= 1.647(1 + 1.214 L/D) D$	$U = 1.25D + 1.5L$ $= 1.25(1 + 1.2L/D) D$
Design ultimate resistance	$R = .17(1 + 2/B_c) \text{SQR}(f_c') b_o d$ $< .33 \text{SQR}(f_c') b_o d$	$R = .2(1 + 2/B_c) \phi_c \text{SQR}(f_c') b_o d$ $< .4 \phi_c \text{SQR}(f_c') b_o d$ $R = .12(1 + 2/B_c) \text{SQR}(f_c') b_o d$ $< .24 \text{SQR}(f_c') b_o d$
Ratio of load/resistance	$U/R(1 + 2/B_c) b_o d \text{SQR}(f_c')$ $= \frac{1.647D(1 + 1.214L/D)}{0.17}$ $= 9.688(1 + 1.214L/D) D$	$U/R(1 + 2/B_c) b_o d \text{SQR}(f_c')$ $= \frac{1.25D(1 + 1.2L/D)}{0.12}$ $= 10.417(1 + 1.2L/D) D$

Example of slab depth calculations :

For the floor plan, shown in Fig. 5-1, the following dimensions were chosen ;

$$f_c' = 30 \text{ MPa,}$$

live load = 5 KN/sq m, and

dead load (including slab weight) = 10 KN/sq m

Solution for an interior column, 400 x 500 mm rectangular section :

$$B_c = 500/400 = 1.25$$

Using the CSA code:

$$U = 1.5 \times 5 + 1.25 \times 10 = 20 \text{ KN/sq m}$$

$$v_c = .2 (1 + 2/1.25) \times 1 \times .6 \times \text{SQR}(30) = 1.71 \text{ MPa}$$

should not be greater than  $(.4 \times 1 \times .6 \times \text{SQR}(30)) = 1.31 \text{ MPa}$

So take  $v_c = 1.31 \text{ MPa}$

$$V_r = V_f = 20 \times 6 \times 5 = 600 \text{ KN}$$

$$d = \text{SQR} \left( \left( \frac{b+h}{4} \right)^2 + \frac{V_r}{v_c/4} \right) - \frac{b+h}{4}$$

$$d = 181 \text{ mm.}$$

Using the ACI code :

$$U = 1.7 \times 5 + 1.4 \times 10 = 22.5 \text{ KN/sq m}$$

$$v_c = .17 (1 + 2/1.25) \text{ SQR}(30) = 2.4 \text{ MPa}$$

should not be greater than  $(.33 \text{ SQR}(30) = 1.82 \text{ MPa})$

So take  $v_c = 1.82 \text{ MPa}$

$$V_n = V_u / \phi_c = (22.5 \times 5 \times 6) / .85 = 794 \text{ KN}$$

$$d = \text{SQR} \left( \left( \frac{900}{4} \right)^2 + \frac{794 \times 1000}{4/1.82} \right) - \frac{900}{4}$$

$$= 175 \text{ mm.}$$

The ratio of the calculated  $v_c$ -ACI over the calculated  $v_c$ -CSA ( $2.4/1.71 = 1.4$ ) is equal to the ratio of  $v_c$  max-ACI over  $v_c$  max-CSA ( $1.82/1.31 = 1.4$ ). So, even if the calculated  $v_c$  does not exceed the maximum limit both codes still give a similar value for  $d$  as shown below :

Assume  $c_1 = 300$  and  $c_2 = 900$ , so  $B_c = 900/300 = 3$ .

Using CSA code:

$$v_c = 1.1 \text{ MPa} < 1.31 \text{ MPa, O.K.}$$

$$d = 176 \text{ mm.}$$

Using ACI code :

$$v_c = 1.55 \text{ MPa} < 2.40 \text{ MPa, O.K.}$$

$d = 167 \text{ mm.}$

From the above example, it can be observed that the two codes give a similar value of slab depth (about 5% difference) as far as punching shear design is concerned.

Summary :

Overall it can be summarized that the punching shear provisions of the CSA code are some 5% more severe than the ACI code.

## CHAPTER 6

### SUMMARY

A design method for the shore - reshore construction schedule presented by Gardner (1979)<sup>3</sup> was adopted to write a computer program in Basic language on an IBM micro-computer .

The design method was generalized to be used for any value of construction live load - dead load ratio and for any combination of shore - reshore levels. It was also updated to include the provisions of the CSA-84 code and to use recent results of the compressive strength of concrete tested by Gardner and Sau (1984)<sup>7,8</sup>.

This method is based on the assumptions that all slabs have equal stiffness and the punching shear strength is the governing criterion in the analysis of flat slabs construction schedule .

The relationship between concrete compressive strength and shear strength was investigated and used in the computer program.

The maturity method was used to establish numerical equations to represent concrete compressive strength with age for types 10 and 30 cements for different curing temperatures.

The computer program provides three methods of analysis as :

1. Input type of shoring system, time of casting, and time of stripping to find out if the cycle is safe or not.
2. Input type of shoring system to find out time of casting, and time of stripping.
3. Input time of casting, and time of stripping to find out type of shoring system.

The computer program offers several options to handle the input data.

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Table 1-1 Load on slab at age of slab for a two-shore plus two-reshore schedule

Slab	Age of slab (cycles after casting)							
	1		2		3		4	
	A	B	A	B	A	B	A	B
1	0.0*	0.0*	1.0*	1.0*	1.0*	1.0*	1.0	1.25
2	1.0*	1.0*	1.5*	1.5*	1.0	1.25	1.0	1.25
3	0.5*	0.5*	1.25	1.50	1.0	1.25	1.0	1.25
4	0.75	1.00	1.50	1.75	1.0	1.25	1.0	1.25
5	0.50	0.75	1.39	1.63	1.0	1.25	1.0	1.25

\* Slab supported on grade.

Table 1-2 Ultimate construction loads on slab at age of slab  
for a two-shore plus two-reshore schedule \*\*

Slab	CSA code				ACI code			
	Age of slab (cycles after casting)							
	1		2		1		2	
	A	B	A	B	A	B	A	B
1	0.0*	0.0*	1.37*	1.37*	0.0*	0.0*	1.54*	1.54*
2	1.37*	1.37*	2.06*	2.06*	1.54*	1.54*	2.31*	2.31*
3	0.69*	0.69*	2.08	2.45	0.77*	0.77*	2.33	2.75
4	1.32	1.70	2.46	2.83	1.48	1.91	2.75	3.18
5	0.94	1.32	2.27	2.64	1.06	1.48	2.54	2.96
6	1.13	1.51	2.36	2.74	1.27	1.69	2.65	3.07
7	1.04	1.42	2.31	2.69	1.16	1.59	2.59	3.02
conver- ged	1.08	1.46	2.33	2.72	1.22	1.64	2.62	3.04

\* Slab supported on grade, so construction live load transmitted directly to ground.

\*\* The results are based on using  $FW = 1.1$  and  $CLR = 0.5$  (see equation 1-1b.)

Table 1-2A Maximum values of Ultimate construction load on slab at age of slab for a two-shore plus two-reshore schedule\*

CSA code				ACI code			
Age of slab (cycles after casting)							
1		2		1		2	
A	B	A	B	A	B	A	B
1.37	1.70	2.46	2.83	1.54	1.91	2.75	3.18
At slab number 2	4	4	4	2	4	4	4

\* a. The results are based on using FW = 1.1 and CLR = 0.5  
(see equation 1-1b.)

b. Slab being cast # = no. of slab + no. of shores.

Table 1-3 Design ultimate load capacity for various live load-  
dead load ratios

Live load / dead load ratio	Design ultimate load capacity multiples of dead load	
	CSA code	ACI code
0.50	2.0	2.25
0.75	2.37	2.67
1.00	2.75	3.10
1.25	3.12	3.53
1.50	3.50	3.95
2.00	4.25	4.80

Table 1-4 Concrete compressive strength development - Gardner and Sau results <sup>7,8</sup>

Cement CSA type	Casting and curing temp. in °C	W/C	Compressive strength in MPa						
			3 days	7 days	14 days	28 days	90 days	180 days	360 days
10	0	0.55	3.8	10.6	17.1	20.2	22.3	22.9	24.5
		0.45	6.7	19.8	28.9	31.2	36.1	35.8*	37.9
		0.35	13.1	26.6	33.2	34.8	42.2	43.5	46.1
	16	0.55	15.9	18.3	23.0	27.3	30.4	32.7	32.0*
		0.45	17.2	20.5	26.0	29.1	33.2	33.5	37.9
		0.35	24.9	27.3	31.3	34.6	39.8	43.4	46.3
	45	0.55	13.2	17.1	19.0	21.7	22.8	24.9	27.9
		0.45	20.8	26.7	29.3	32.8	35.1	36.3	38.5
		0.35	39.3	43.7	48.2	52.0	57.9	62.7	63.7
30	0	0.55	13.4	28.5	37.2	39.0	40.5	41.5	41.5*
		0.45	23.1	42.3	48.0	52.2	55.7	57.1	60.1
		0.35	40.1	57.3	62.3	64.6	70.7	71.7	67.5*
	22	0.55	31.7	37.4	40.3	42.4	43.7	48.2	50.9
		0.45	39.7	45.4	47.8	49.5	52.4	54.1	57.3
		0.35	47.0	53.2	56.5	59.3	64.0	67.4	69.9

\* Experimental error ( wrong reading )

Table 2-1 Relationship between member strength and developed cylinder strength

$f_c'/f_{c'28}$	1.00	0.75	0.50	0.25
	-----	-----	-----	-----
$(f_c'/f_{c'28})^{0.80}$	1.00	0.79	0.57	0.33
$(f_c'/f_{c'28})^{0.50}$	1.00	0.87	0.71	0.50
$(f_c'/f_{c'28})^{0.33}$	1.00	0.91	0.78	0.63
Flexural/ flexural(28 days)				
<hr/>				
$P = 1.4/ f_y$	1.00	0.98	0.94	0.81
$P = 0.5 P_b$	1.00	0.93	0.85	over- reinforced
				-----

where :

- $f_c'$  = specified compressive strength of concrete in MPa,  
 $f_{c'28}$  = specified compressive strength of concrete after 28 days in MPa,  
 $f_y$  = specified yield strength of non-prestressed reinforcement in MPa,  
 $p$  = ratio of non-prestressed reinforcement, and  
 $P_b$  = reinforcement ratio producing balanced conditions.

Table 3-1 Concrete compressive strength development - Klieger results<sup>1/</sup>

Cement ASTM type	Casting and curing temp. in °C	Compressive strength in MPa					
		1 day	3 days	7 days	28 days	3 months*	1 year*
I	48.9	14.1	19.6	23.7	28.3	32.6	36.7
	40.5	12.7	22.1	26.5	32.5	36.2	40.4
	32.2	10.3	21.3	28.7	36.1	39.3	43.0
	22.8	9.7	21.5	30.9	41.7	43.8	49.6
	12.8	4.0	13.3	25.8	43.1	52.0	55.8
	4.4	0.5	5.0	14.7	35.7	49.1	53.3
	-3.9**	0.3	3.2	4.3	10.9	43.4	50.7
III	48.9	22.6	26.5	28.7	32.5	34.7	37.4
	40.5	20.7	26.9	31.6	35.3	39.0	42.7
	32.2	19.0	29.6	34.5	39.4	40.7	47.3
	22.2	18.2	27.1	32.9	39.6	43.6	47.6
	12.8	9.9	21.9	27.6	37.7	44.7	47.4
	4.4	2.5	13.8	28.7	43.2	53.4	59.1
	-3.9**	1.0	9.4	17.5	27.7	44.3	47.8

Cement content of all mixes is 4.2 sacks per cu m.

Net. W/C constant for each cement type.

Compression, 150 mm, modified cubes.

All data are converted from Klieger original data in Imperial units.

\* Cured at 22.8 °C after first 28 days.

\*\* Casted at 4.4 °C and placed immediately in room at -3.9 °C.

Table 3-2 Values of the constants a, B, a/B for equations 3-5 and 3-6. <sup>23</sup>

<u>Type of curing</u>	<u>Cement type</u>	<u>a</u>	<u>B</u>	<u>a/B</u>
Moist cured	I	4.00	0.85	4.71
	III	2.30	0.92	2.50
Steam cured	I	1.00	0.95	1.05
	III	0.70	0.98	0.71

Table 3-3 Analysis of Concrete compressive strength - age data - Gardner and Sau results 7,8- to determine the limiting compressive strength  $S_u$  in MPa

A. Based on 28 days to 1 year data :

<u>Cement CSA type</u>	<u>Casting and curing temp. in °C</u>	<u>W/C</u>	<u><math>S_u</math></u>	<u>One-year strength</u>
10	45	0.55	26.3	27.9
		0.45	37.7	38.5
	16	0.55	32.9	32.0
		0.45	36.5	37.9
	0	0.55	24.3	24.5
		0.45	38.0	37.9
30	22	0.55	49.2	50.9
		0.45	56.0	57.3
	0	0.55	41.7	41.5
		0.45	59.1	60.1

B. Based on 90 days to 1 year data :

<u>Cement CSA type</u>	<u>Casting and curing temp. in °C</u>	<u>W/C</u>	<u><math>S_u</math></u>	<u>One-year strength</u>
10	45	0.55	25.3	27.9
		0.45	37.7	38.5
	16	0.55	33.2	32.0
		0.45	38.1	37.9
	0	0.55	29.4	24.5
		0.45	39.2	37.9
30	22	0.55	53.8	50.9
		0.45	58.3	57.3
	0	0.55	42.0	41.5
		0.45	60.9	60.1

Table 3-4 Analysis of Concrete compressive strength - age data to determine the rate constant\*

A. Using Klieger data :

Cement ASTM type	Casting and curing temp. in °C	$t_0$ days	$K_t$ 1/days
I	-3.9	6.9	0.067
	4.4	6.8	0.070
	12.8	1.8	0.153
	22.8	-13.6	0.080
	32.2	- 8.6	0.111
	40.5	-11.7	0.090
	48.9	-22.1	0.042
III	-3.9	4.8	0.142
	4.4	0.0	0.103
	12.8	0.5	0.180
	22.8	-10.3	0.110
	32.2	-34.5	0.050
	40.5	-15.1	0.102
	48.9	-18.1	0.122

B. Using Gardner and Sau data :

Cement CSA type	Casting and curing temp. in °C	W/C	$t_0$ days	$K_t$ 1/days
10	45	0.55	-38.4	0.040
		0.45	-24.7	0.080
	16	0.55	15.8	0.570
		0.45	-40.7	0.040
	0	0.55	-14.6	0.080
		0.45	-19.0	0.106
30	22	0.55	-22.0	0.080
		0.45	-44.0	0.080
	0	0.55	3.3	0.440
		0.45	-22.7	0.100

\* Based on using all the data .

Table 3-5 Analysis of Concrete compressive strength - age data to determine the rate constant\*

A. Using Klieger data :

Cement ASTM type	Casting and curing temp. in °C	$t_0$ days	$K_t$ 1/days
I	-3.9	-0.25	0.016
	4.4	0.81	0.056
	12.8	0.37	0.126
	22.8	-0.05	0.244
	32.2	-0.16	0.296
	40.5	-0.79	0.283
	48.9	-1.39	0.241
III	-3.9	0.45	0.091
	4.4	0.63	0.140
	12.8	-0.46	0.217
	22.8	-1.05	0.305
	32.2	-0.83	0.394
	40.5	-1.36	0.370
	48.9	-1.98	0.430

B. Using Gardner and Sau data :

Cement CSA type	Casting and curing temp. in °C	W/C	$t_0$ days	$K_t$ 1/days
10	45	0.55	-0.22	0.232
		0.45	0.01	0.334
	16	0.55	-0.75	0.170
		0.45	-0.62	0.173
	0	0.55	0.61	0.106
		0.45	0.78	0.158
30	22	0.55	-0.08	0.414
		0.45	0.03	0.577
	0	0.55	0.73	0.317
		0.45	0.62	0.345

\* Based on data up to 7 days only.

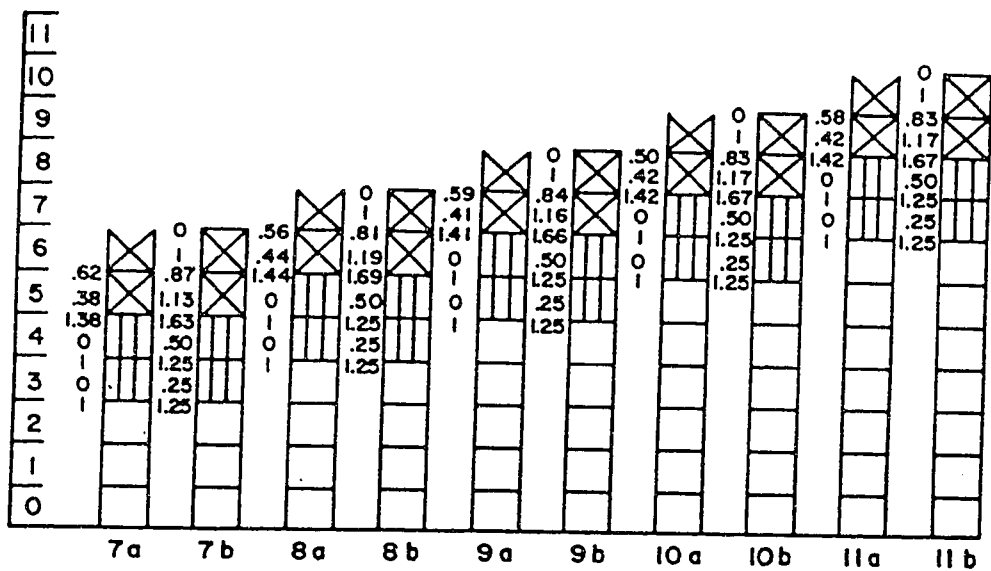
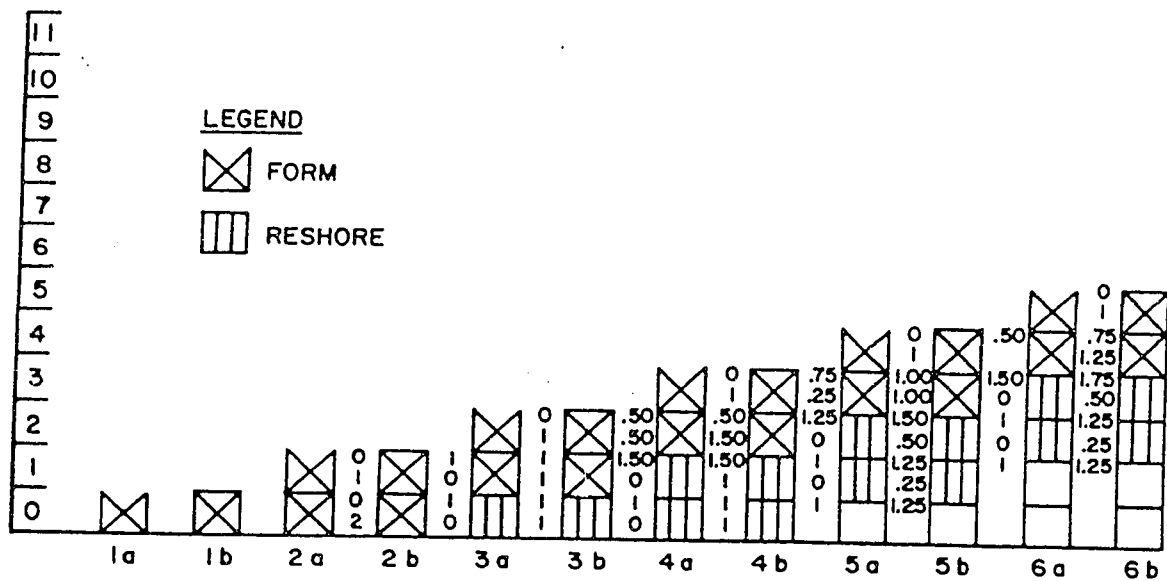


Fig. 1-1 Shore, reshore, and slab load ratios for a two-shore plus two-reshore construction schedule.(3)

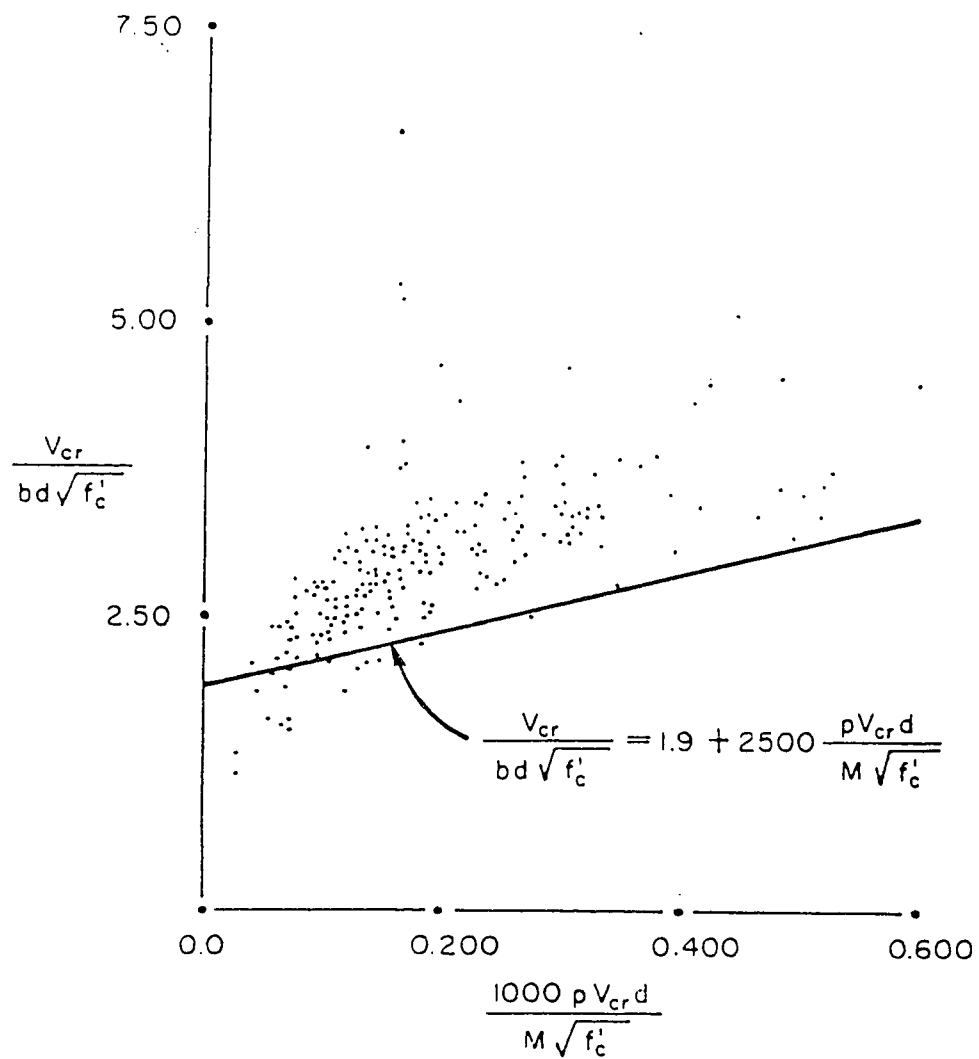


Fig. 2-1 Plot of ACI nominal shear strength formula for all  $a/d$  ratios; for  $a/d \geq 2.0$ ,  $M_u = U_u(a-d)$ ; for  $a/d \leq 2.0$ ,  $M_u = U_u d$ . (9)

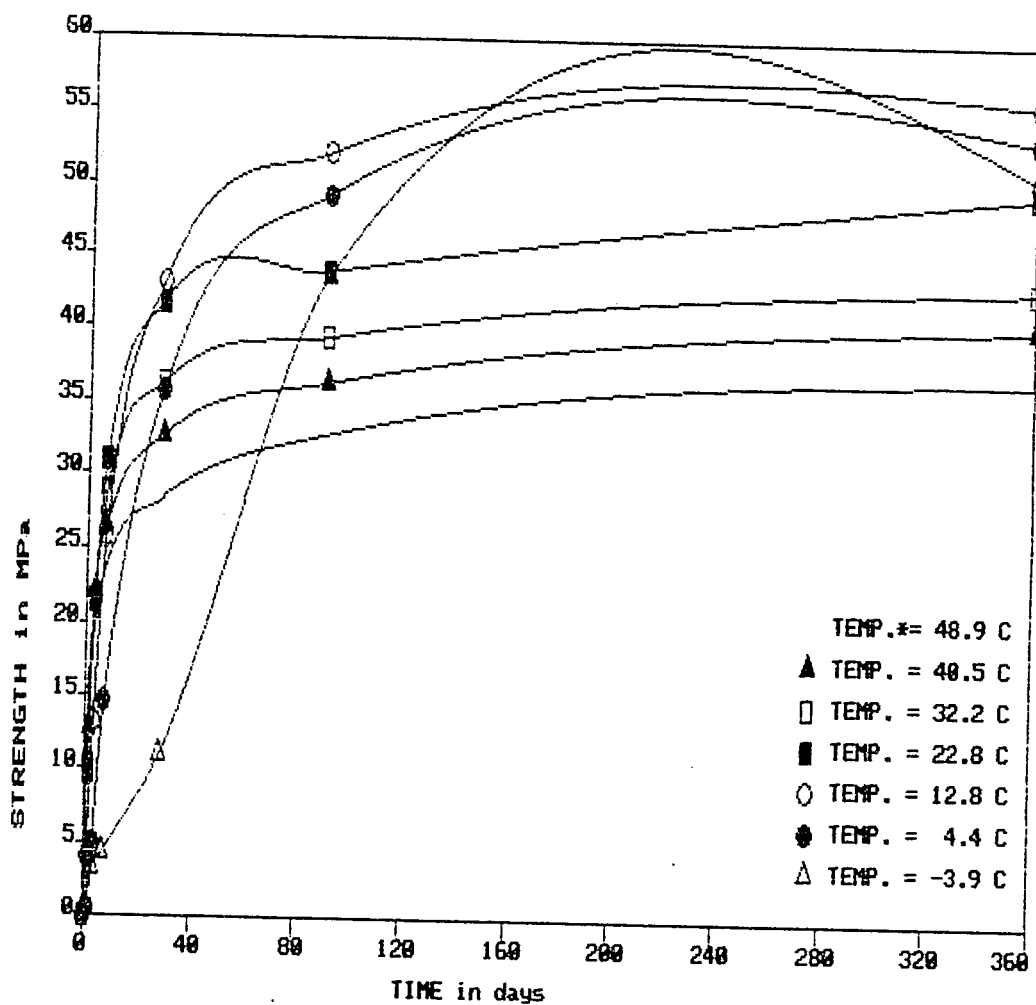


Fig. 3-1 Compressive strength development for ASTM type I cement concrete - Klieger results.

- \* Curing temperature in degree Celsius (refer to Table 3-1).
- These curves were plotted by using smooth curve fit between the points-

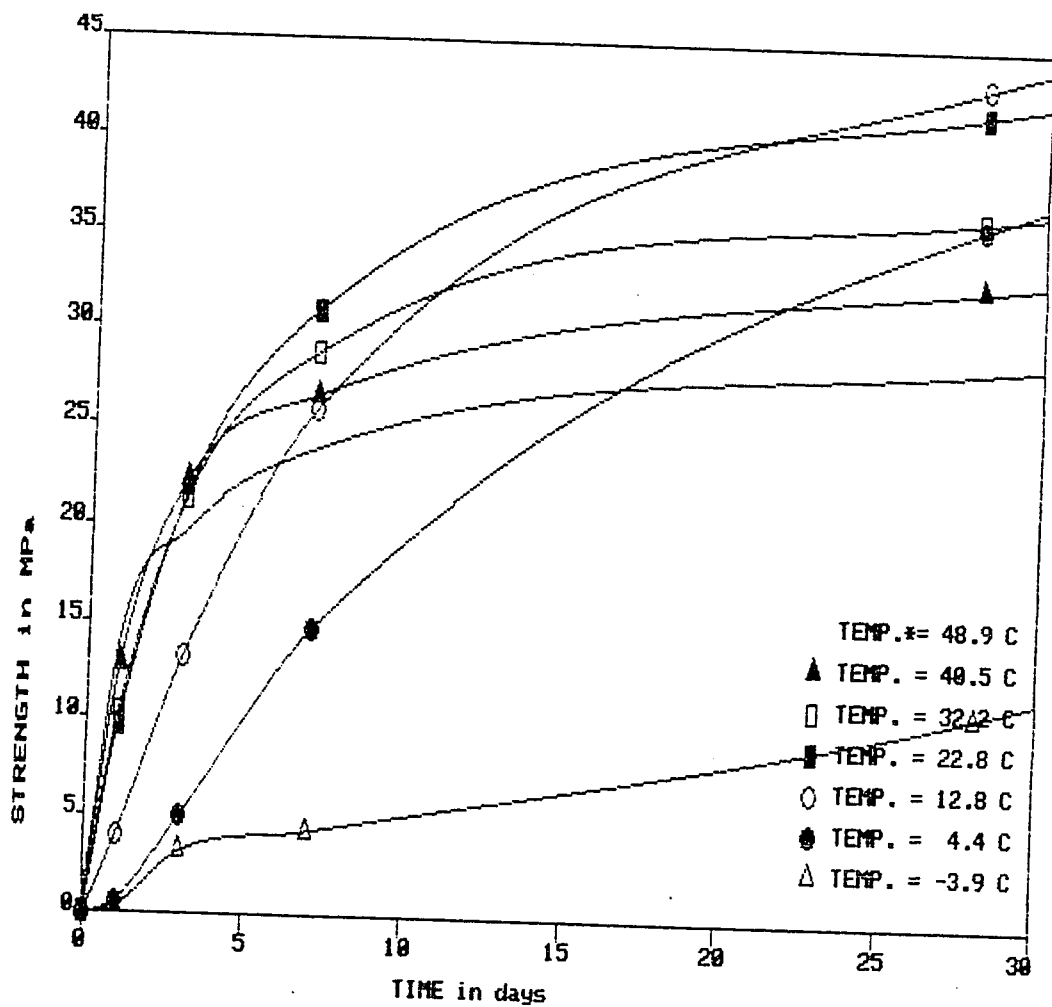


Fig. 3-2 Compressive strength development for ASTM type I cement concrete - Klieger results (data for a period of 30 days only).

- \* Curing temperature in degree Celsius (refer to Table 3-1).
- These curves were plotted by using smooth curve fit between the points-.

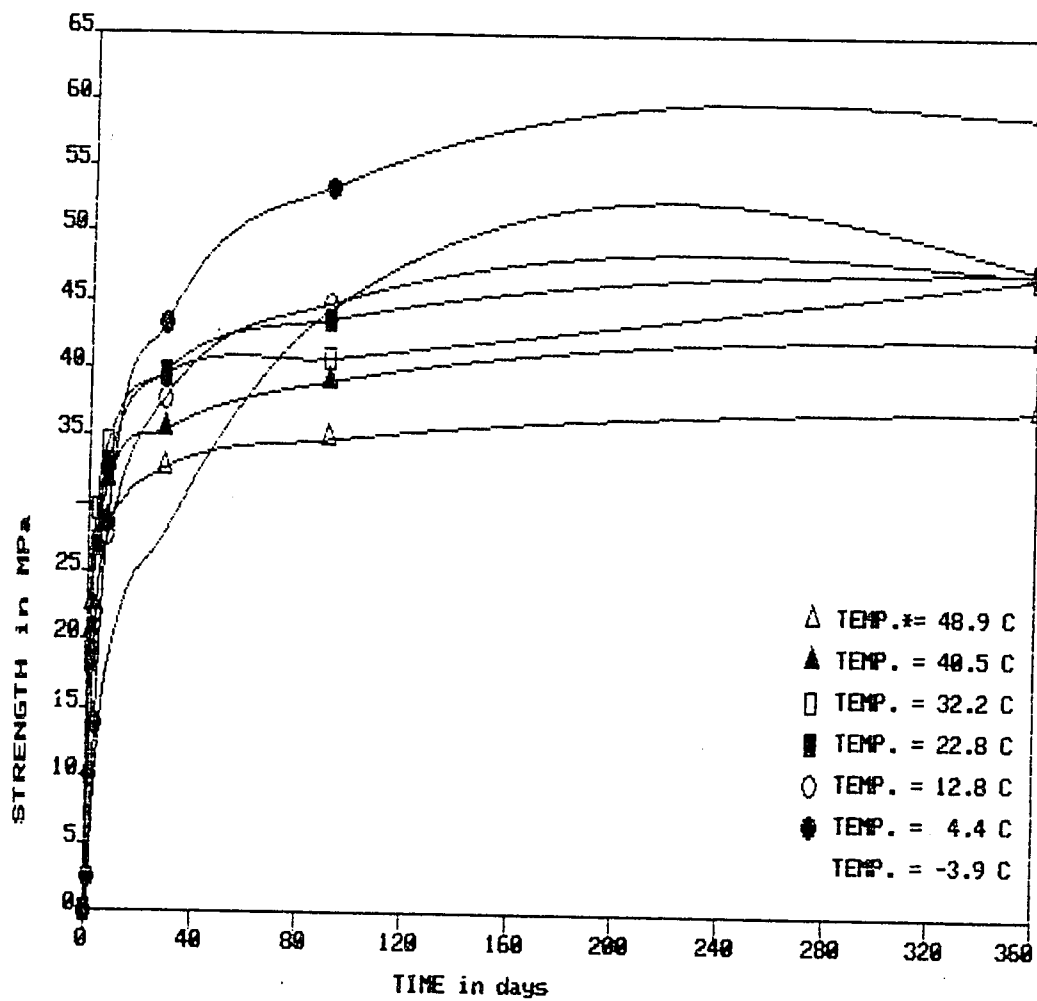


Fig. 3-3 Compressive strength development for ASTM type III cement concrete - Klieger results.

- \* Curing temperature in degree Celsius (refer to Table 3-1).
- These curves were plotted by using smooth curve fit between the points-.

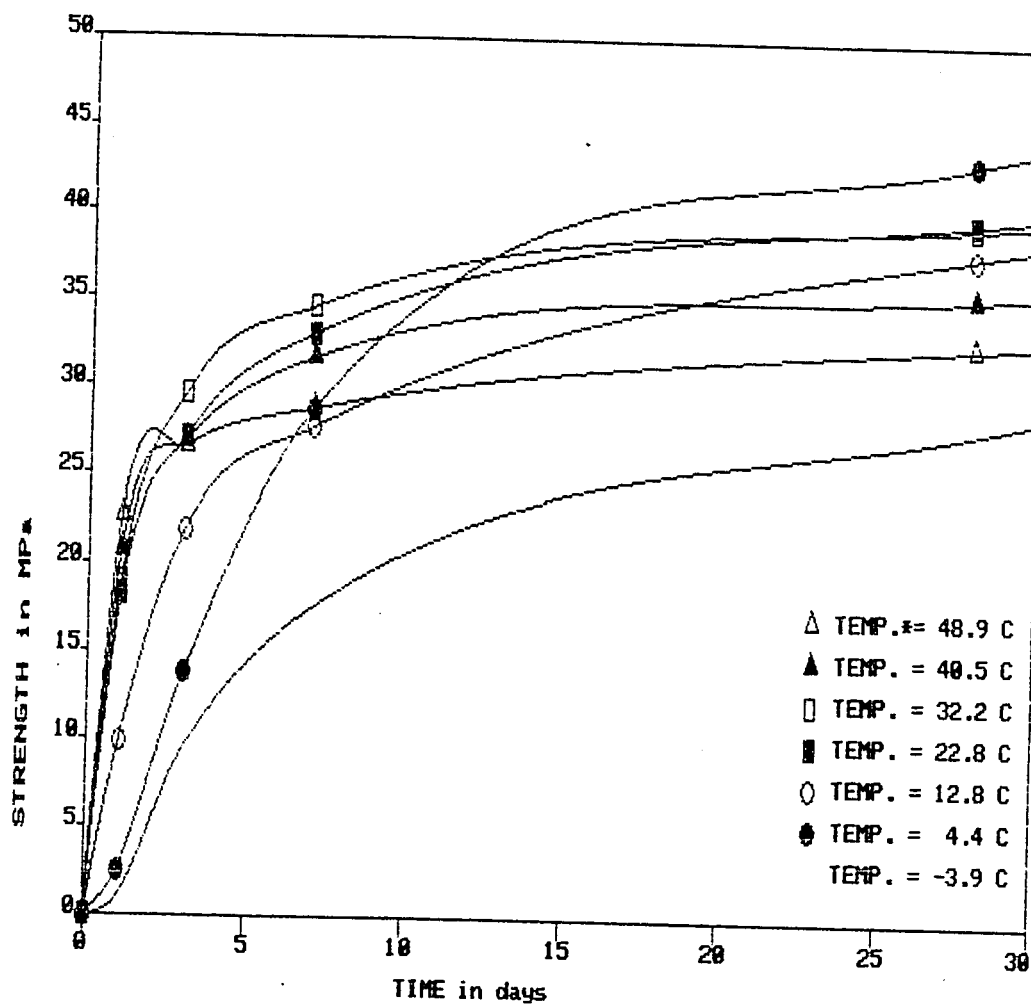


Fig. 3-4 Compressive strength development for ASTM type III cement concrete - Klieger results (data for a period of 30 days only).

- \* Curing temperature in degree Celsius (refer to Table 3-1).
- These curves were plotted by using smooth curve fit between the points-.

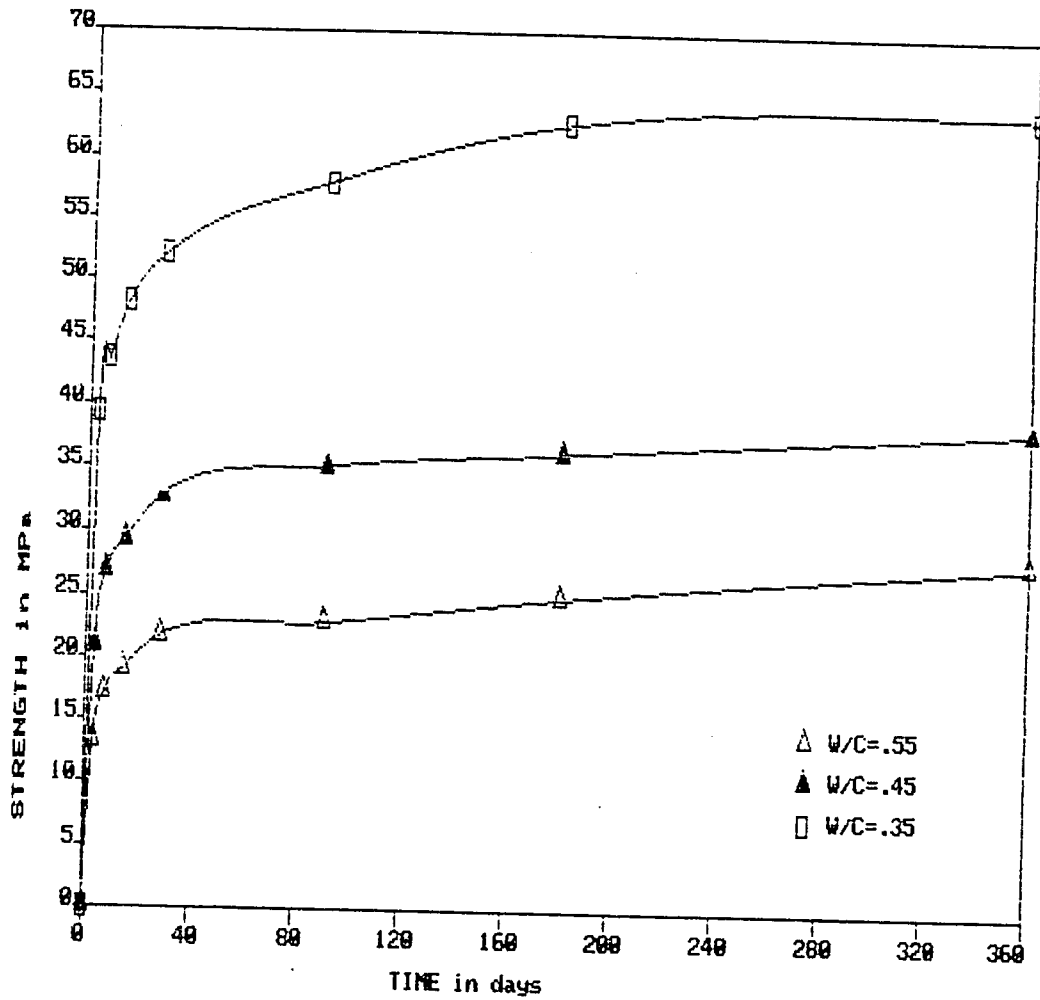


Fig. 3-5 Compressive strength development for CSA type 10 Cement concrete cured at 45 degree Celsius - Gardner and Sau results (refer to Table 1-4).

- These curves were plotted by using smooth curve fit between the points-.

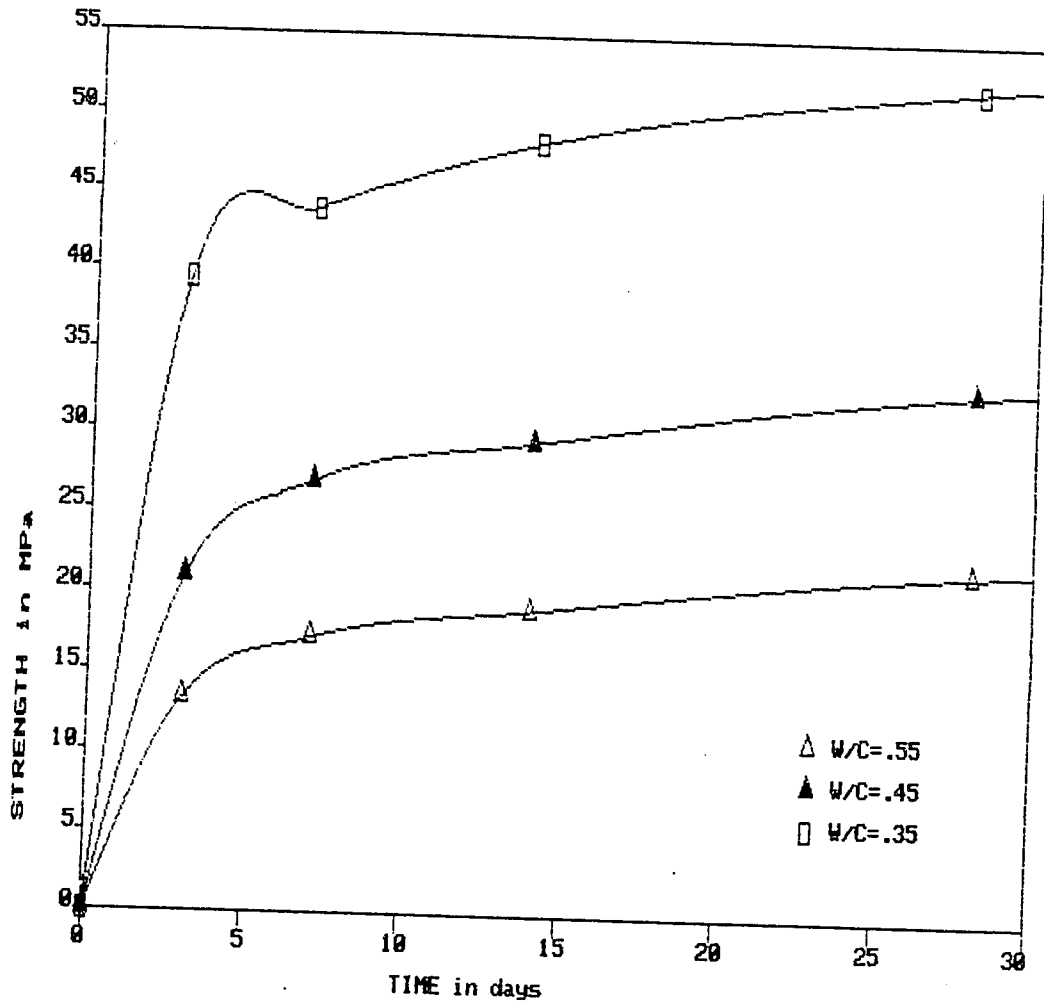


Fig. 3-6 Compressive strength development for CSA type 10 Cement concrete cured at 45 degree Celsius - Gardner and Sau results (data for a period of 30 days only, refer to Table 1-4).

- These curves were plotted by using smooth curve fit between the points -.

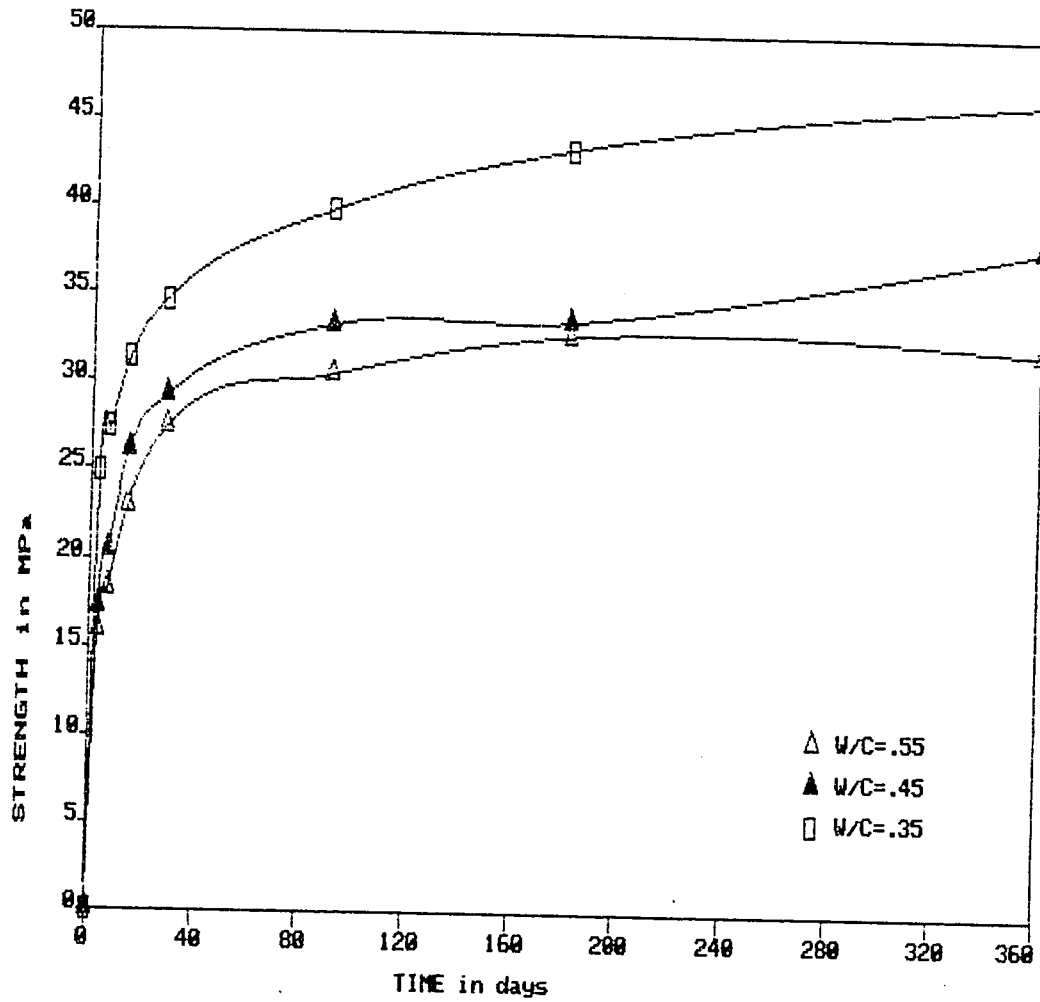


Fig. 3-7 Compressive strength development for CSA type 10 Cement concrete cured at 16 degree Celsius - Gardner and Sau results (refer to Table 1-4).

- These curves were plotted by using smooth curve fit between the points -.

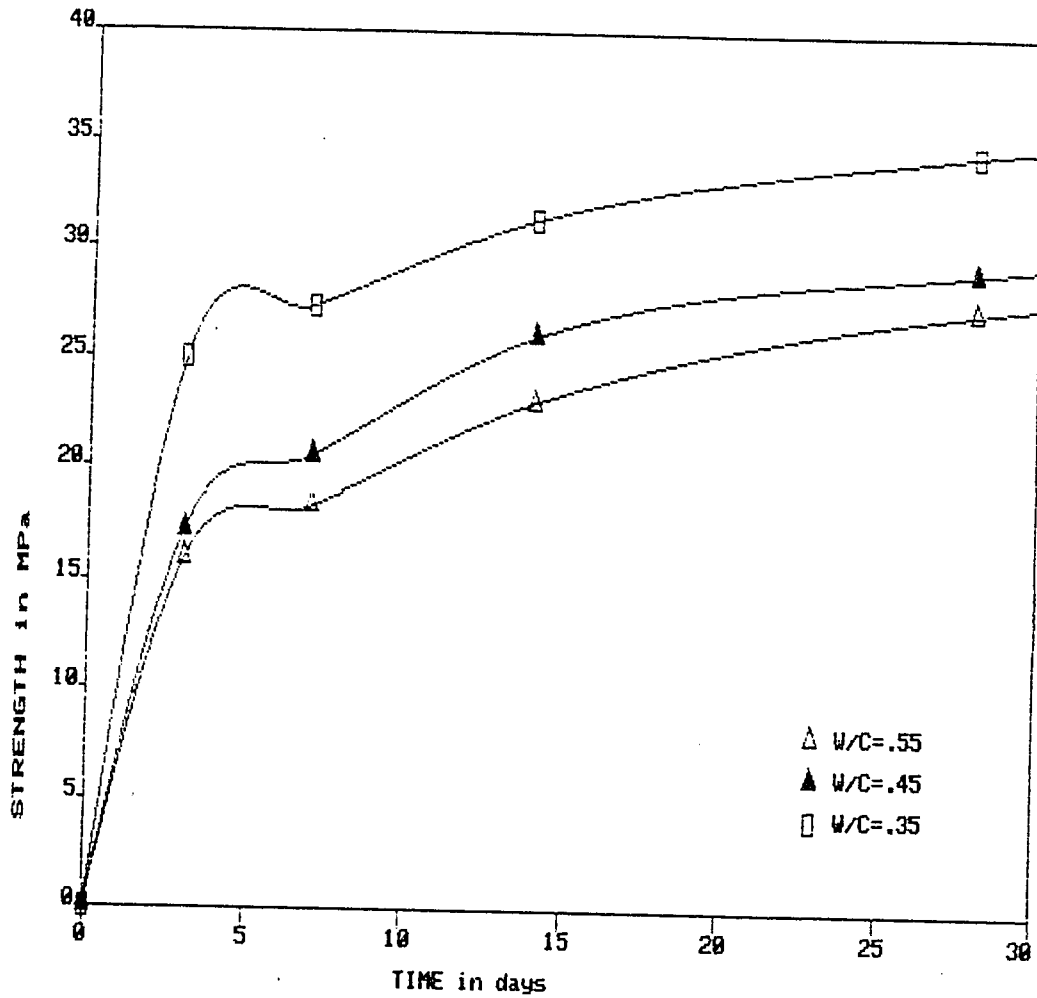


Fig. 3-8 Compressive strength development for CSA type 10 Cement concrete cured at 16 degree Celsius - Gardner and Sau results (data for a period of 30 days only, refer to Table 1-4).

- These curves were plotted by using smooth curve fit between the points-.

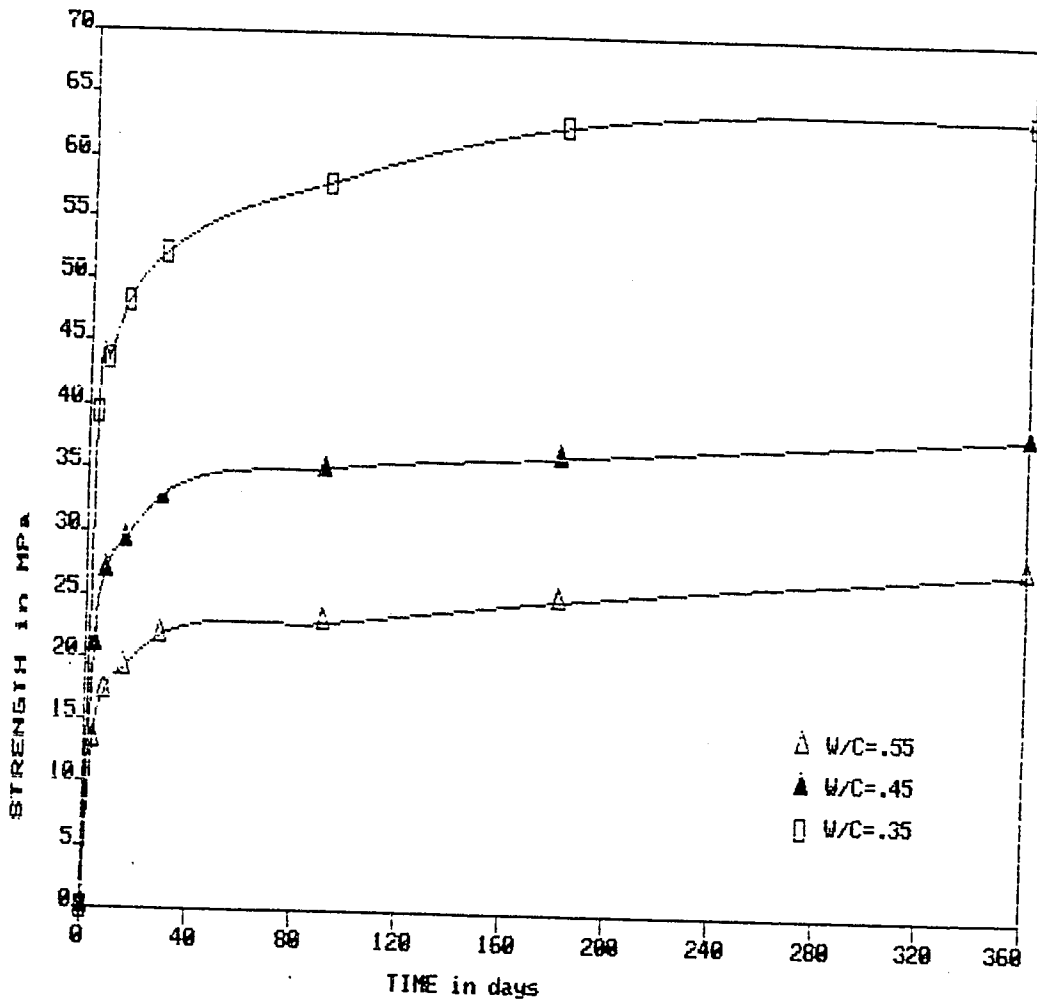


Fig. 3-9 Compressive strength development for CSA type 10 Cement concrete cured at 0 degree Celsius - Gardner and Sau results (refer to Table 1-4).

- These curves were plotted by using smooth curve fit between the points-.

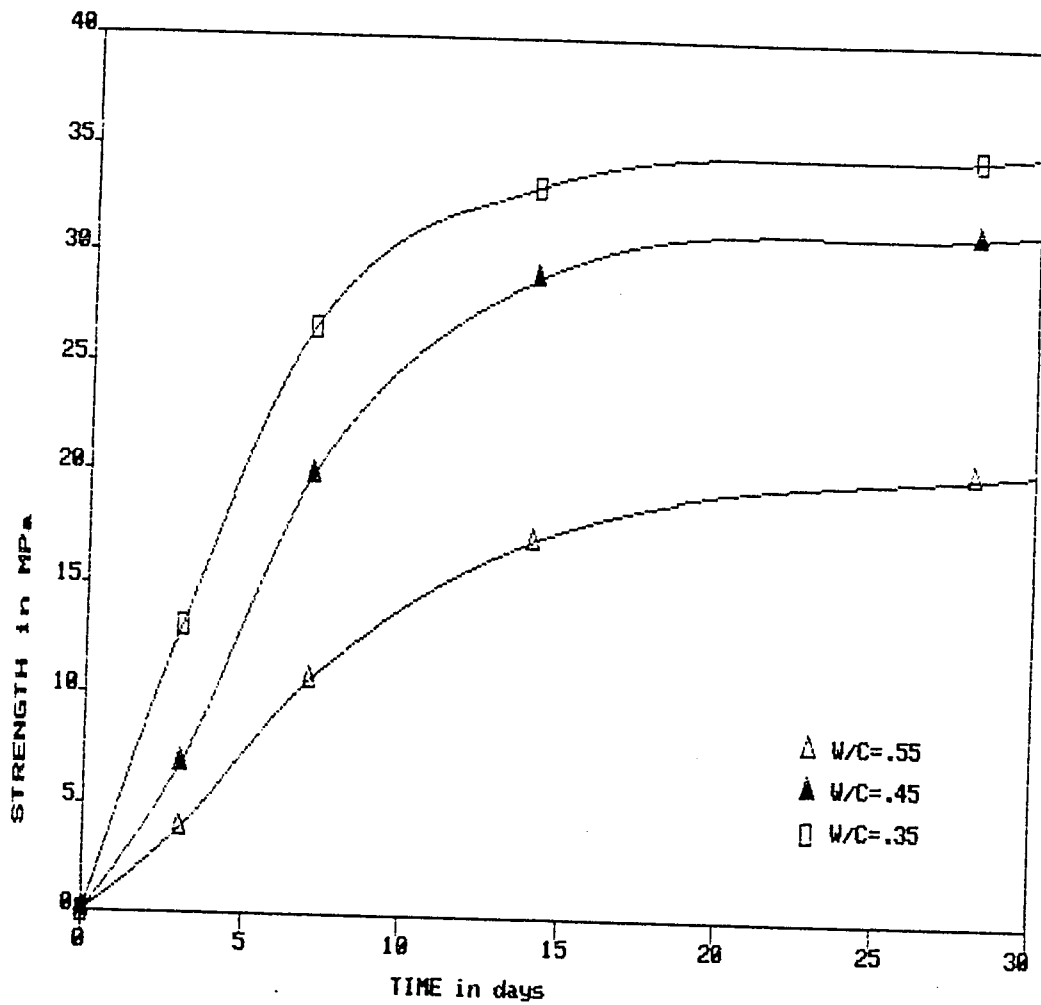


Fig. 3-10 Compressive strength development for CSA type 10 Cement concrete cured at 0 degree Celsius - Gardner and Sau results (data for a period of 30 days only, refer to Table 1-4).

- These curves were plotted by using smooth curve fit between the points -.

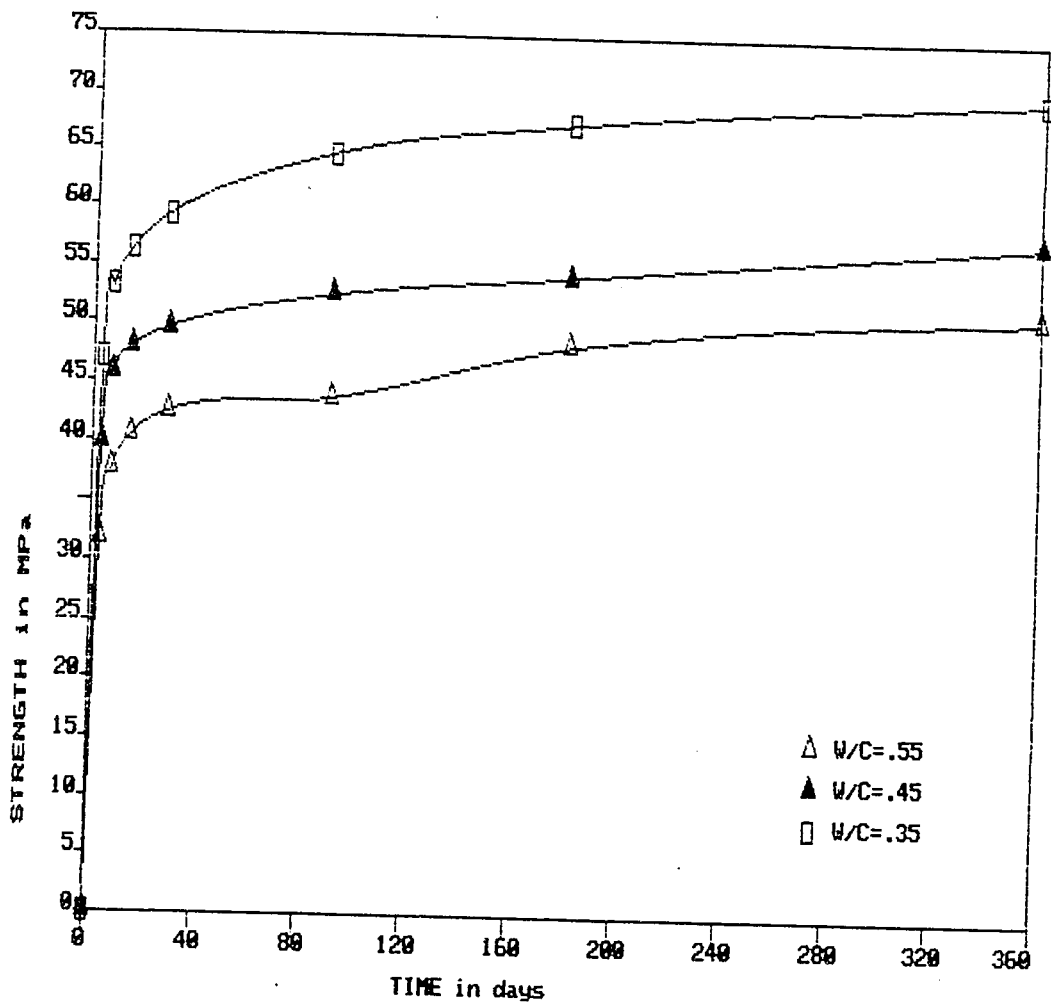


Fig 3-11 Compressive strength development for CSA type 30 Cement concrete cured at 22 degree Celsius - Gardner and Sau results (refer to Table 1-4).

- These curves were plotted by using smooth curve fit between the points -.

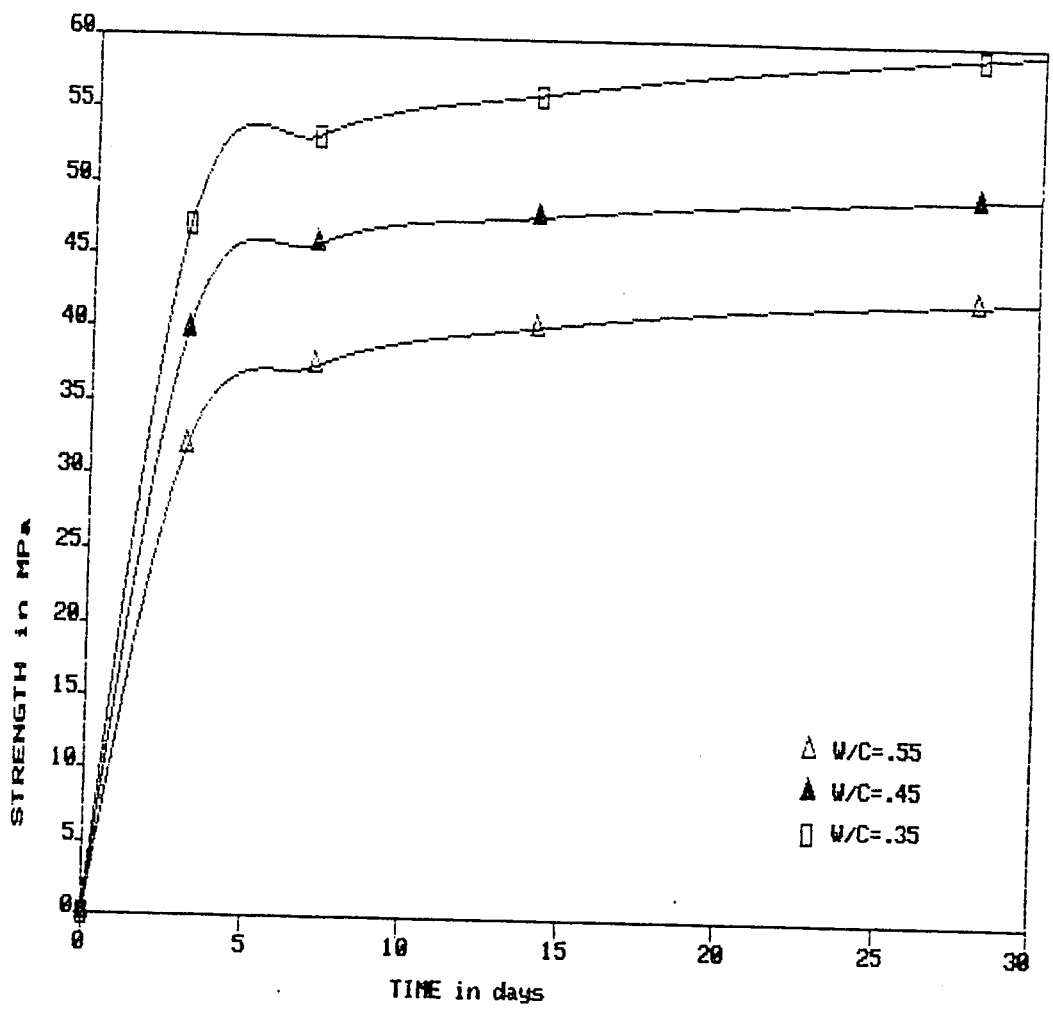


Fig. 3-12 Compressive strength development for CSA type 30 Cement concrete cured at 22 degree Celsius - Gardner and Sau results (data for a period of 30 days only, refer to Table 1-4).

- These curves were plotted by using smooth curve fit between the points -.

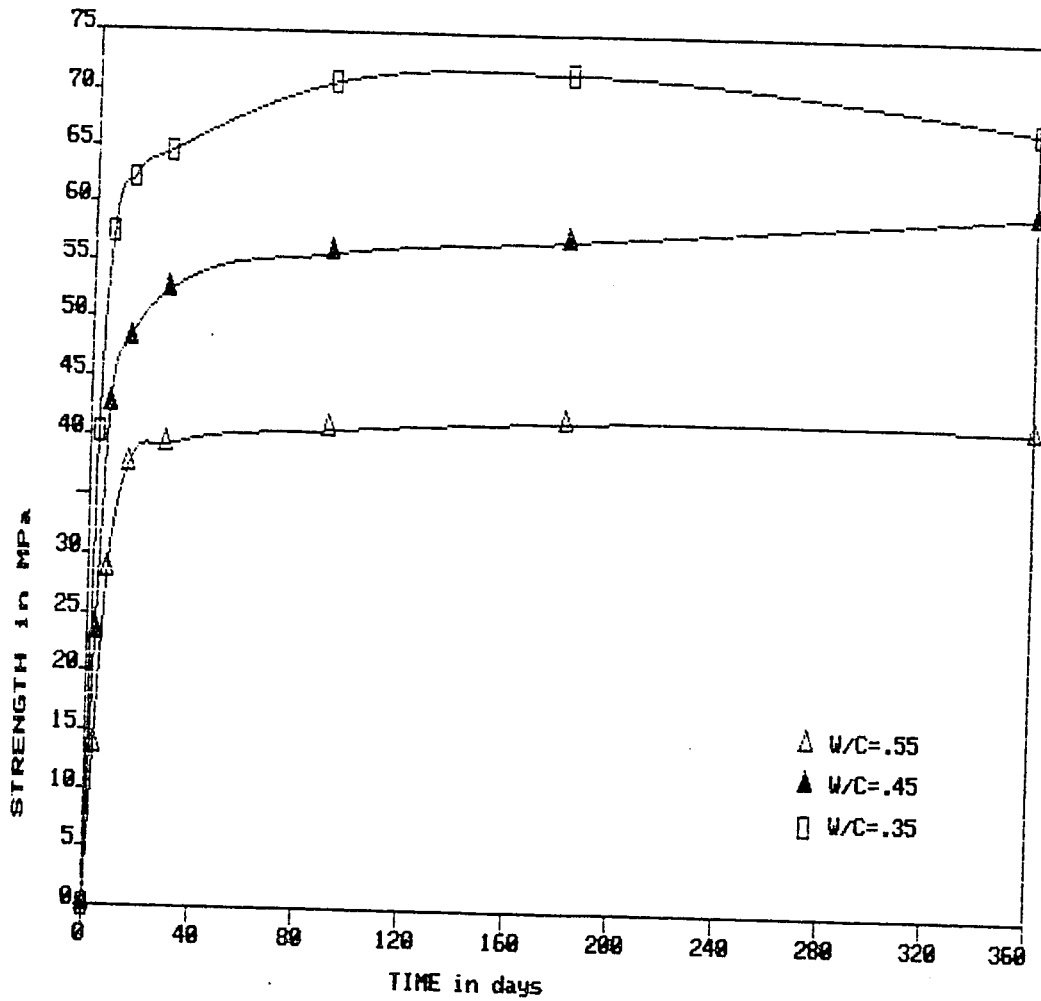


Fig. 3-13 Compressive strength development for CSA type 30 Cement concrete cured at 0 degree Celsius - Gardner and Sau results (refer to Table 1-4).

- These curves were plotted by using smooth curve fit between the points-.

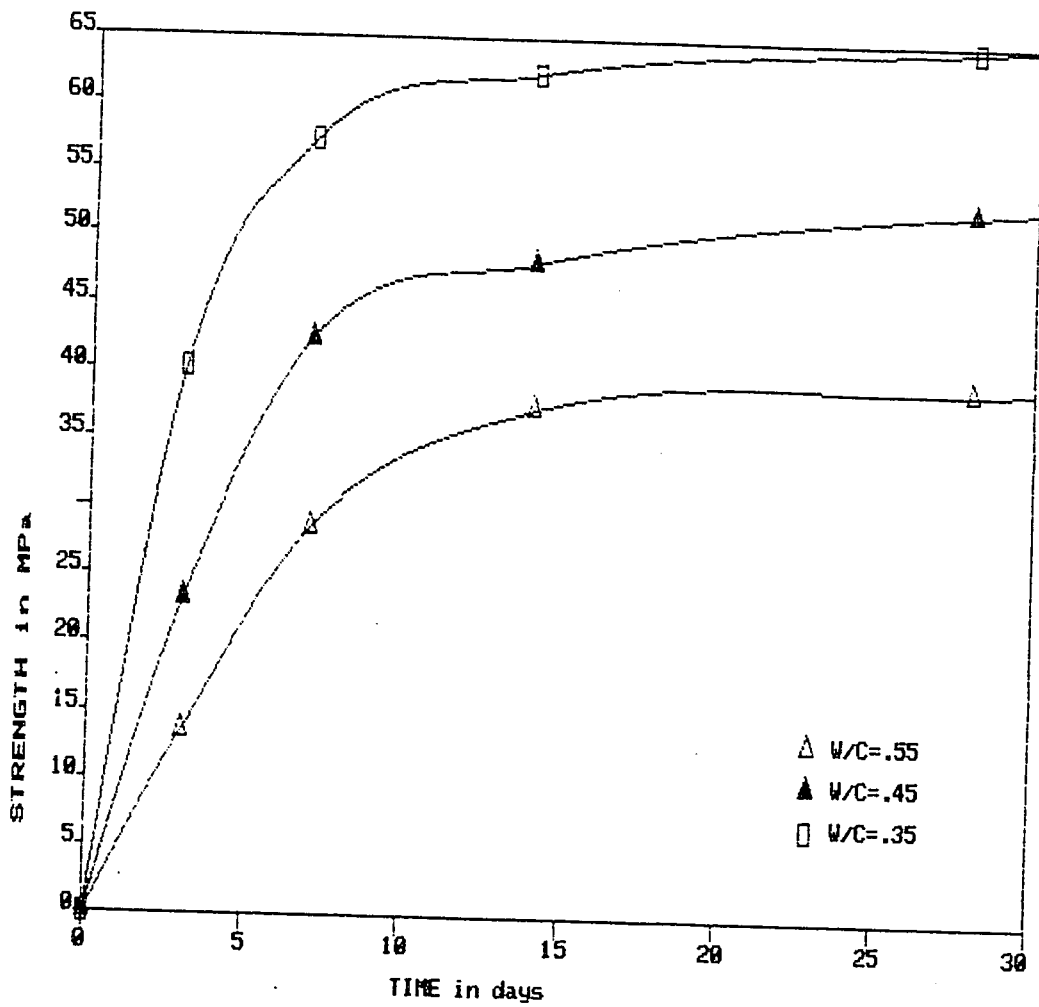


Fig. 3-14 Compressive strength development for CSA type 30 Cement concrete cured at 0 degree Celsius - Gardner and Sau results (data for a period of 30 days only, refer to Table 1-4).

- These curves were plotted by using smooth curve fit between the points -.

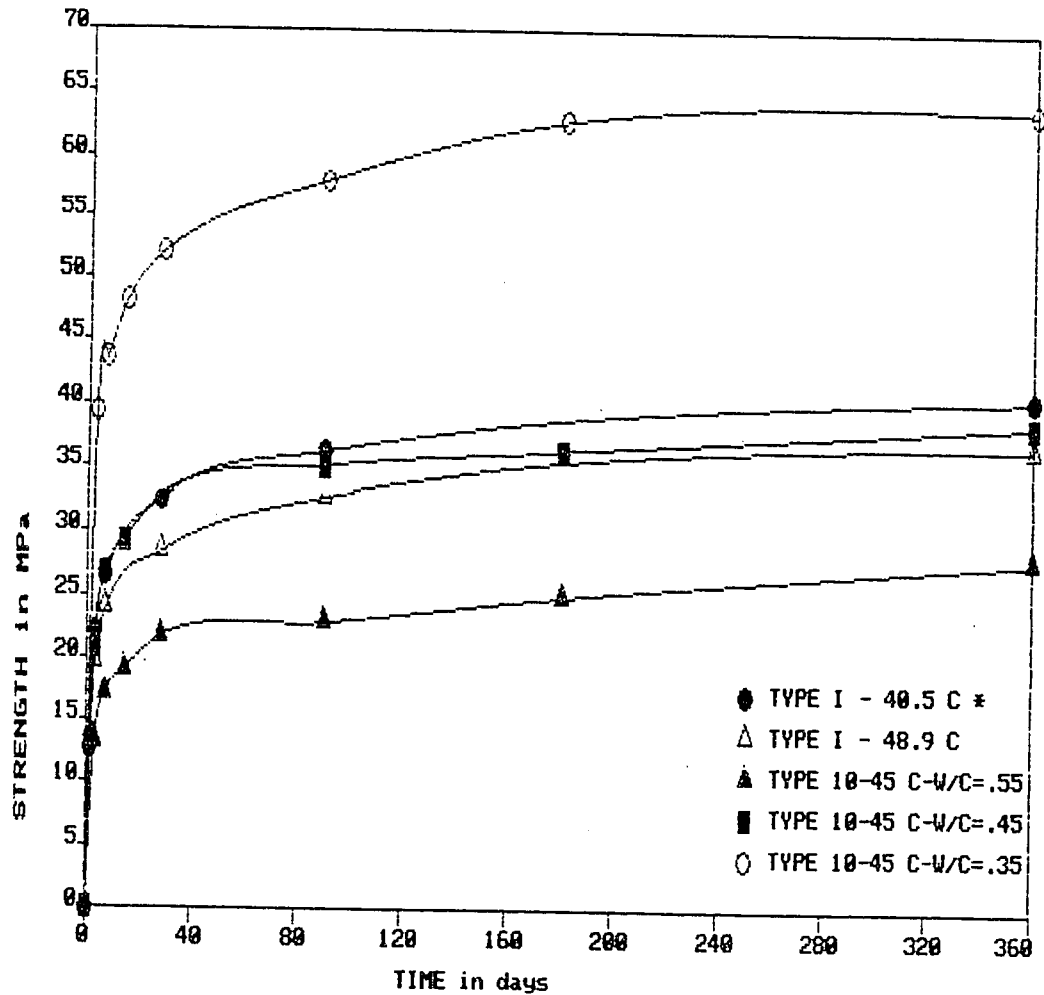


Fig. 3-15 Comparison between Klieger results of concrete compressive strength -using ASTM type I cement and cured at 40.5 and 48.9 degree Celsius-, and Gardner and Sau results -using CSA type 10 cement and cured at 45 degree Celsius (refer to Tables 1-4 and 3-1).

- \* Curing temperature in degree Celsius.
- These curves were plotted by using smooth curve fit between the points-.

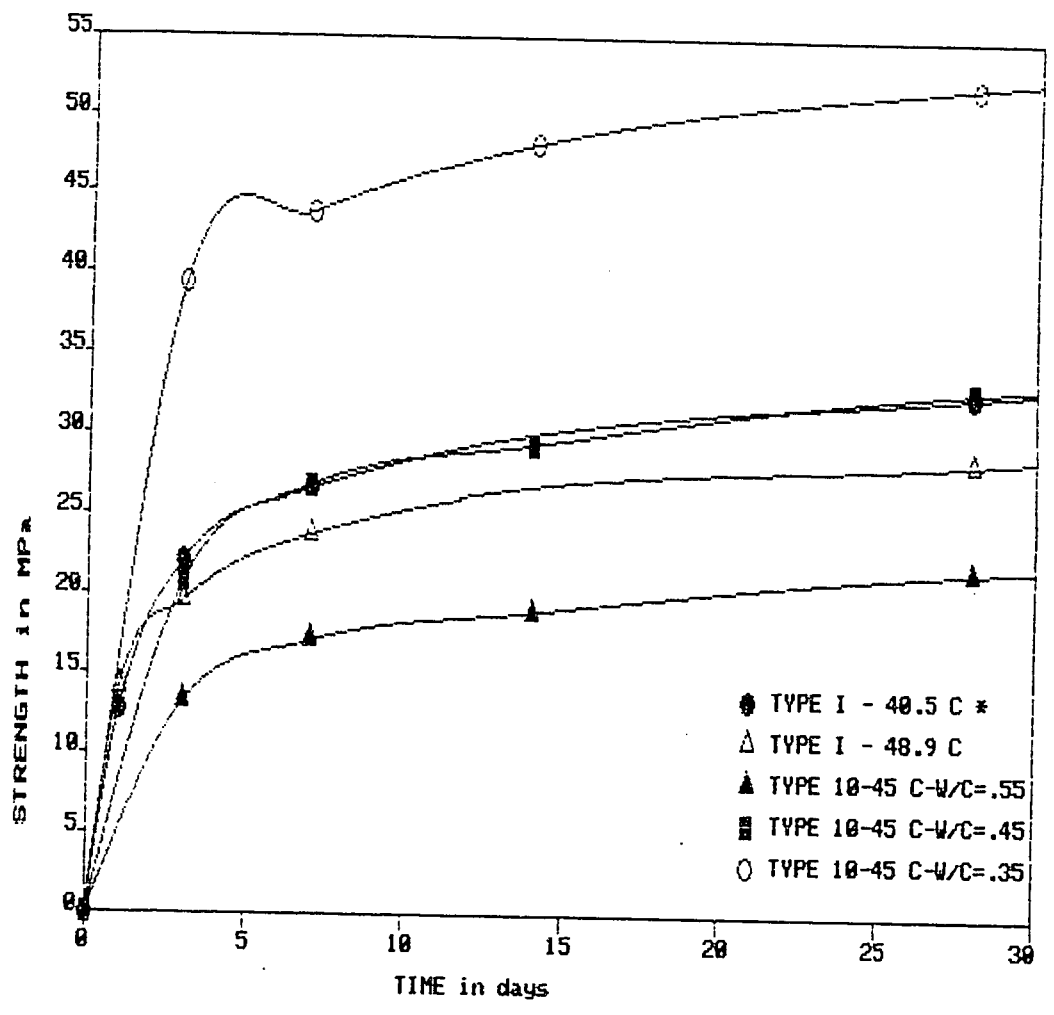


Fig. 3-16 Comparison between Klieger results of concrete compressive strength -using ASIM type I cement and cured at 40.5 and 48.9 degree Celsius-, and Gardner and Sau results -using CSA type 10 cement and cured at 45 degree Celsius (data for a period of 30 days only, refer to Tables 1-4 and 3-1).

\* Curing temperature in degree Celsius.  
- These curves were plotted by using smooth curve fit between the points-.

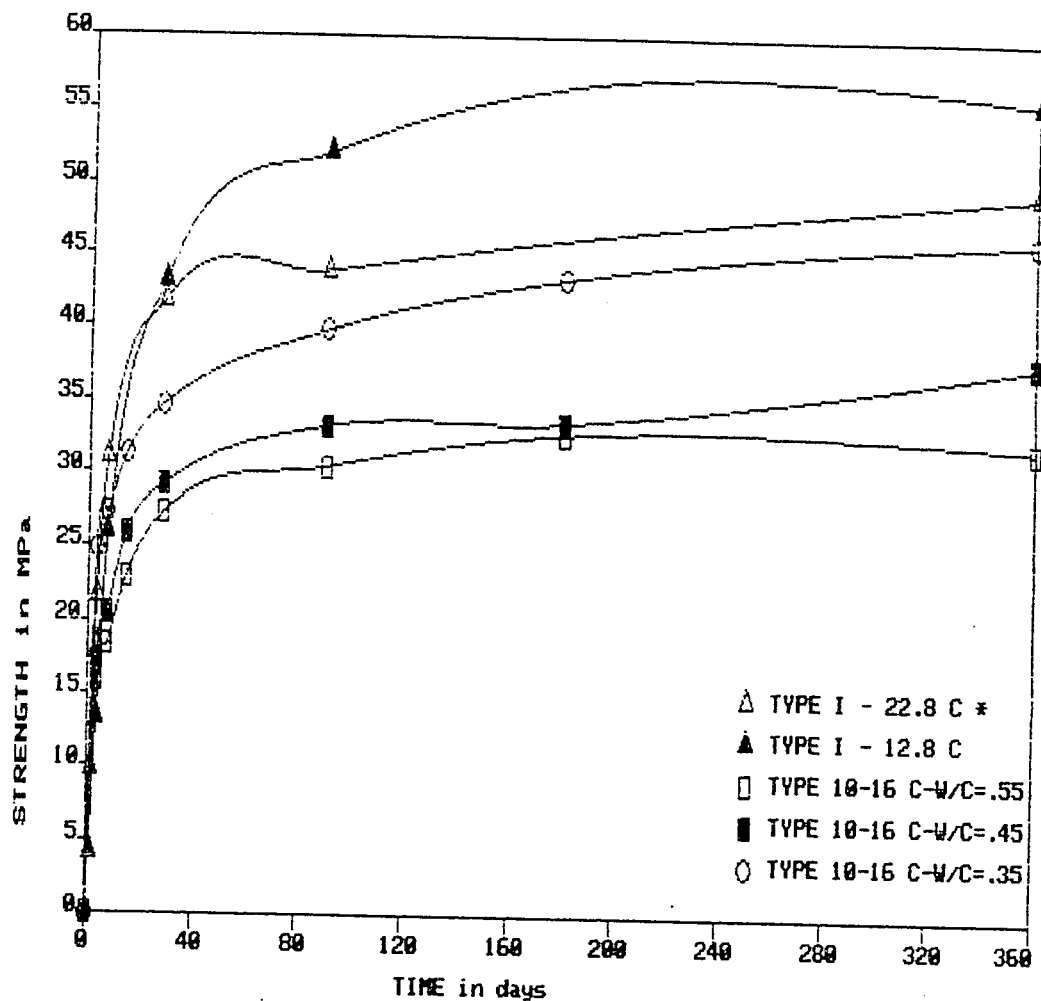


Fig. 3-17 Comparison between Klieger results of concrete compressive strength -using ASIM type I cement and cured at 22.8 and 12.8 degree Celsius-, and Gardner and Sau results -using CSA type 10 cement and cured at 16 degree Celsius (refer to Tables 1-4 and 3-1).

- \* Curing temperature in degree Celsius.
- These curves were plotted by using smooth curve fit between the points-.

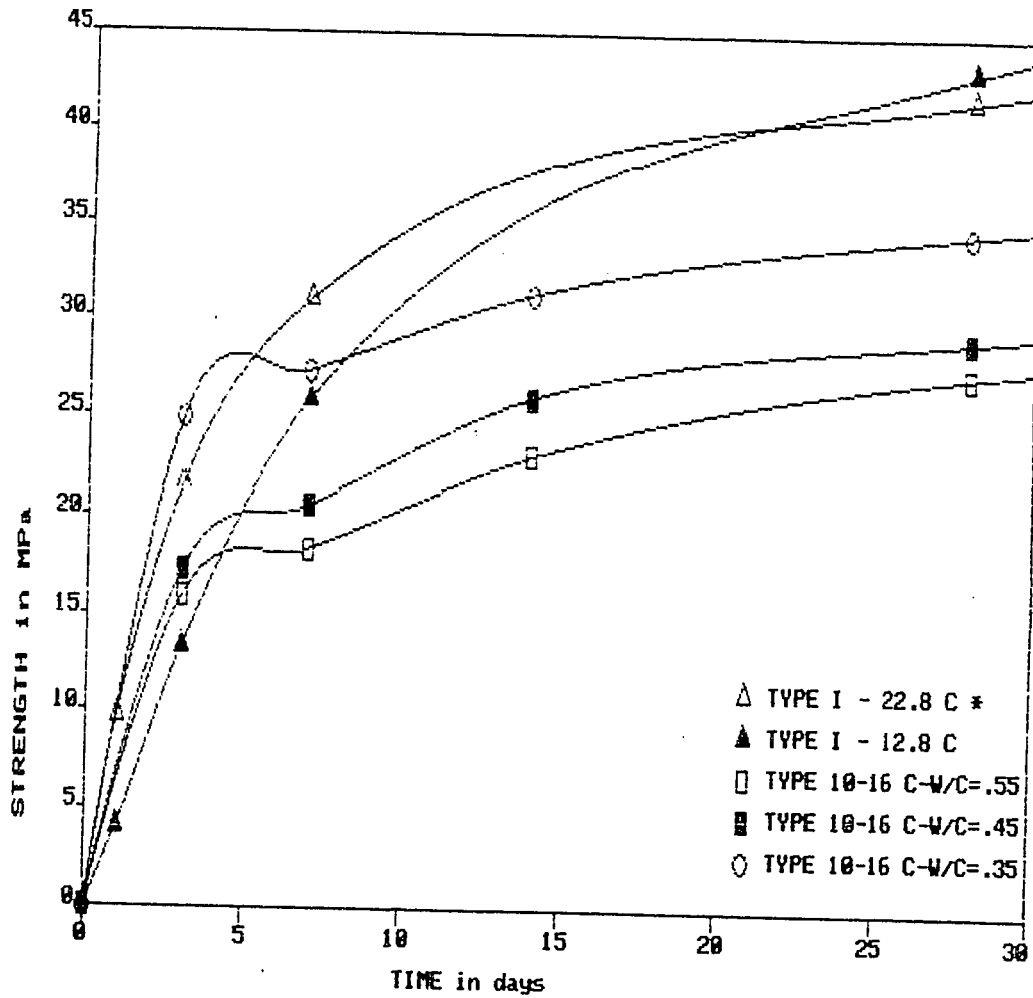


Fig. 3-18 Comparison between Klieger results of concrete compressive strength -using ASTM type I cement and cured at 22.8 and 12.8 degree Celsius-, and Gardner and Sau results -using CSA type 10 cement and cured at 16 degree Celsius (data for a period of 30 days only, refer to Tables 1-4 and 3-1).

- \* Curing temperature in degree Celsius.
- These curves were plotted by using smooth curve fit between the points-.

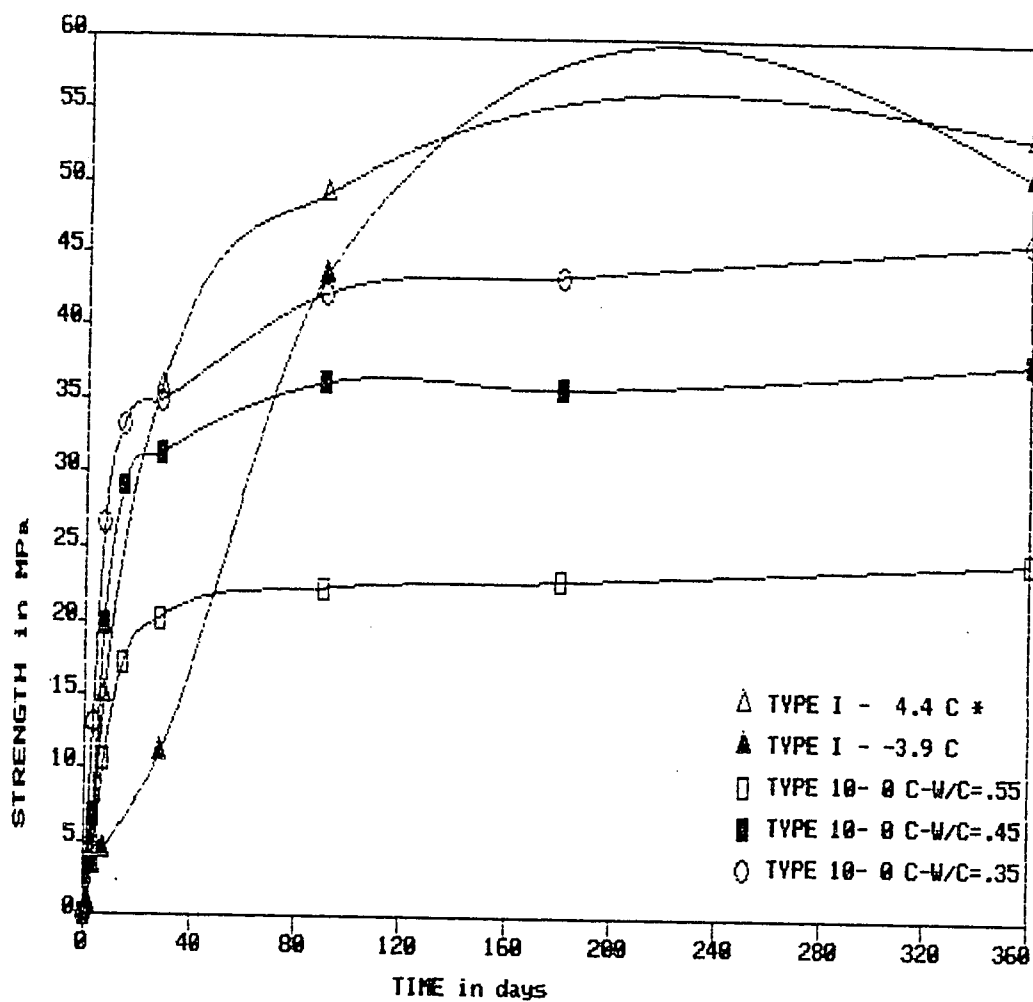


Fig. 3-19 Comparison between Klieger results of concrete compressive strength -using ASTM type I cement and cured at 4.4 and -3.9 degree Celsius-, and Gardner and Sau results -using CSA type 10 cement and cured at 0 degree Celsius. (refer to Tables 1-4 and 3-1).

\* Curing temperature in degree Celsius.  
 - These curves were plotted by using smooth curve fit between the points-.

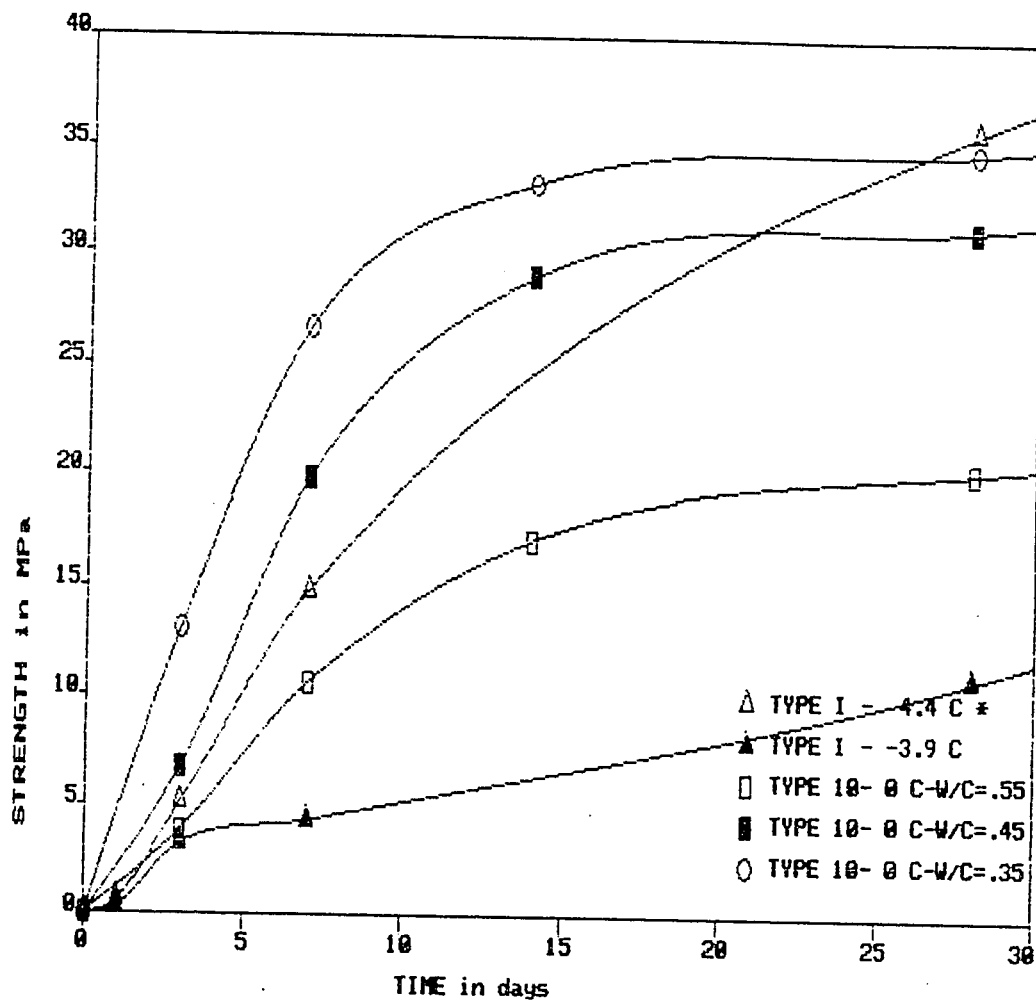


Fig. 3-20 Comparison between Klieger results of concrete compressive strength -using ASTM type I cement and cured at 4.4 and -3.9 degree Celsius-, and Gardner and Sau results -using CSA type 10 cement and cured at 0 degree Celsius. (data for a period of 30 days only, refer to Tables 1-4 and 3-1).

- \* Curing temperature in degree Celsius.
- These curves were plotted by using smooth curve fit between the points-.

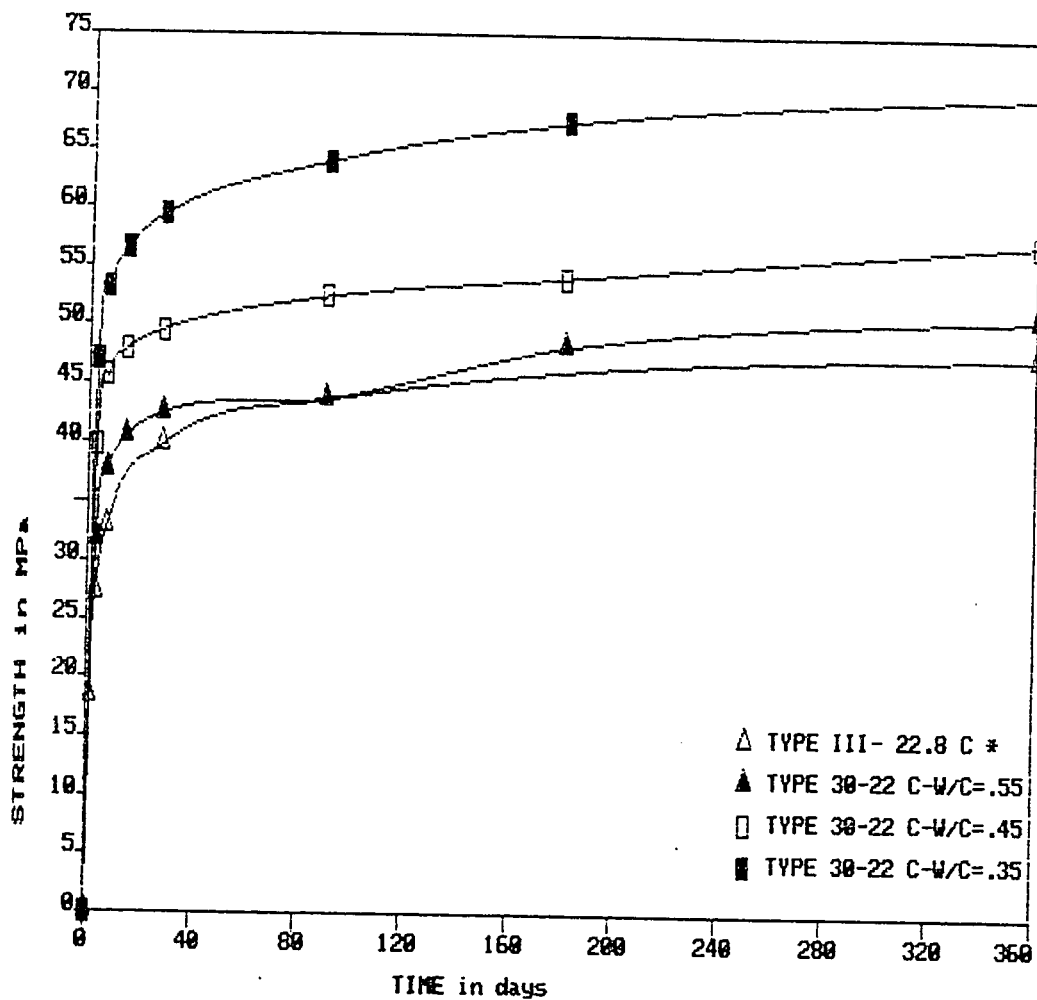


Fig. 3-21 Comparison between Klieger results of concrete compressive strength -using ASTM type III cement and cured at 22.8 degree Celsius-, and Gardner and Sau results -using CSA type 30 cement and cured at 22 degree Celsius (refer to Tables 1-4 and 3-1).

- \* Curing temperature in degree Celsius.
- These curves were plotted by using smooth curve fit between the points-.

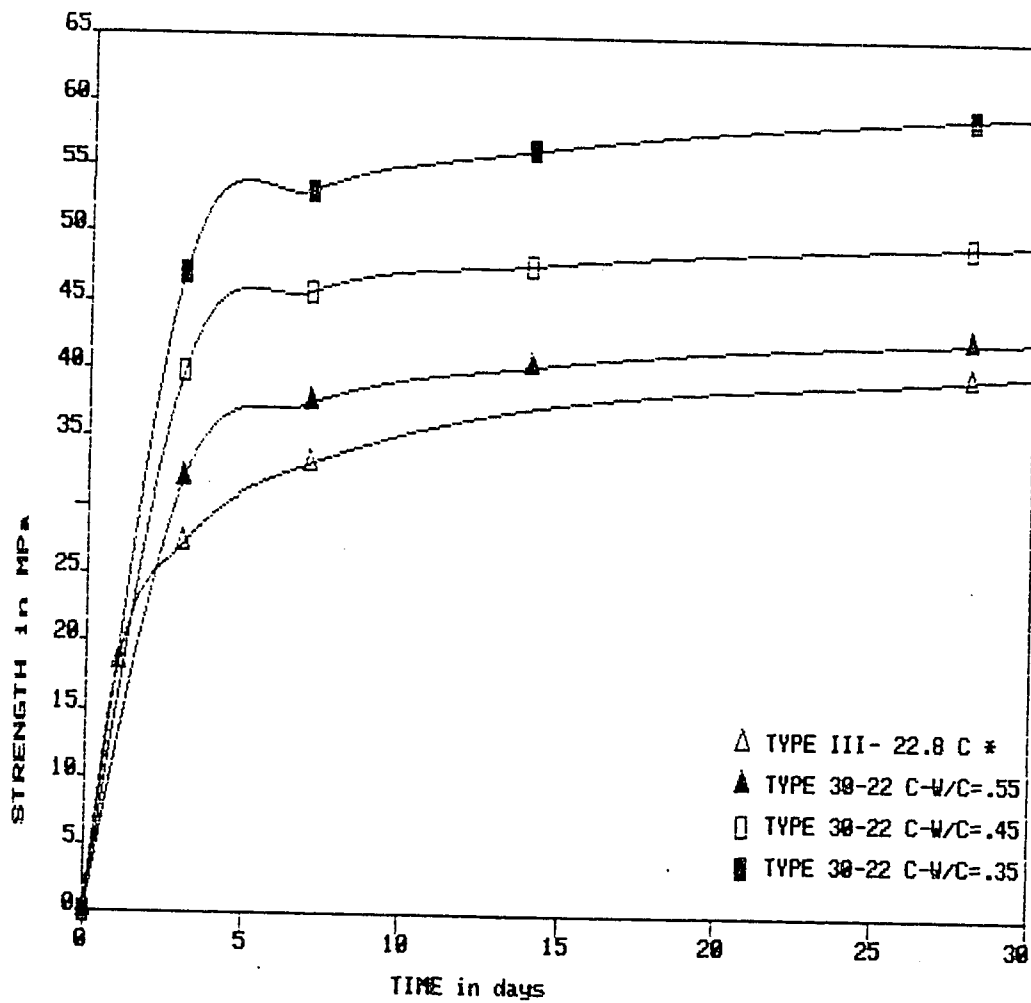


Fig. 3-22 Comparison between Klieger results of concrete compressive strength -using ASTM type III cement and cured at 22.8 degree Celsius-, and Gardner and Sau results -using CSA type 30 cement and cured at 22 degree Celsius (data for a period of 30 days only, refer to Tables 1-4 and 3-1).

\* Curing temperature in degree Celsius.  
 - These curves were plotted by using smooth curve fit between the points-.

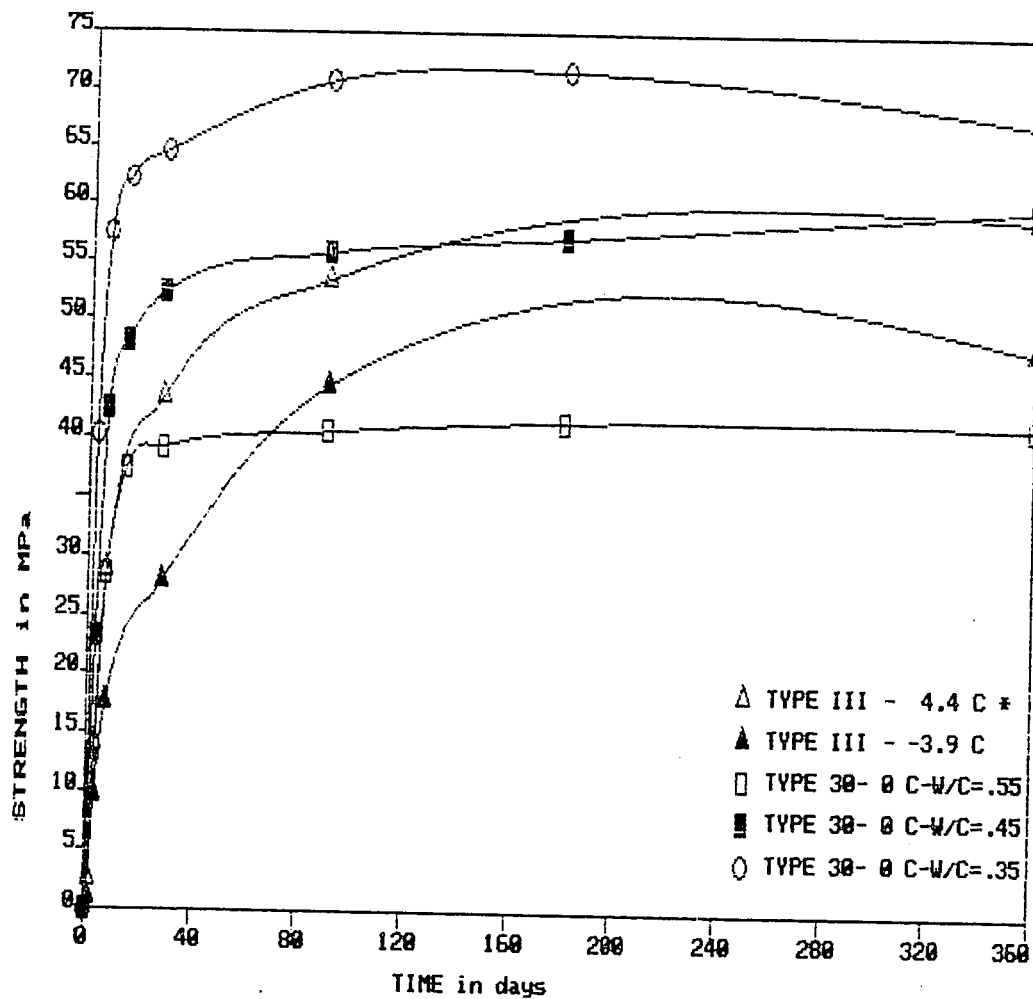


Fig. 3-23 Comparison between Klieger results of concrete compressive strength -using ASIM type III cement and cured at 4.4 and -3.9 degree Celcius-, and Gardner and Sau results -using CSA type 30 cement and cured at 0 degree Celcius. (refer to Tables 1-4 and 3-1).

- \* Curing temperature in degree Celcius.
- These curves were plotted by using smooth curve fit between the points-.

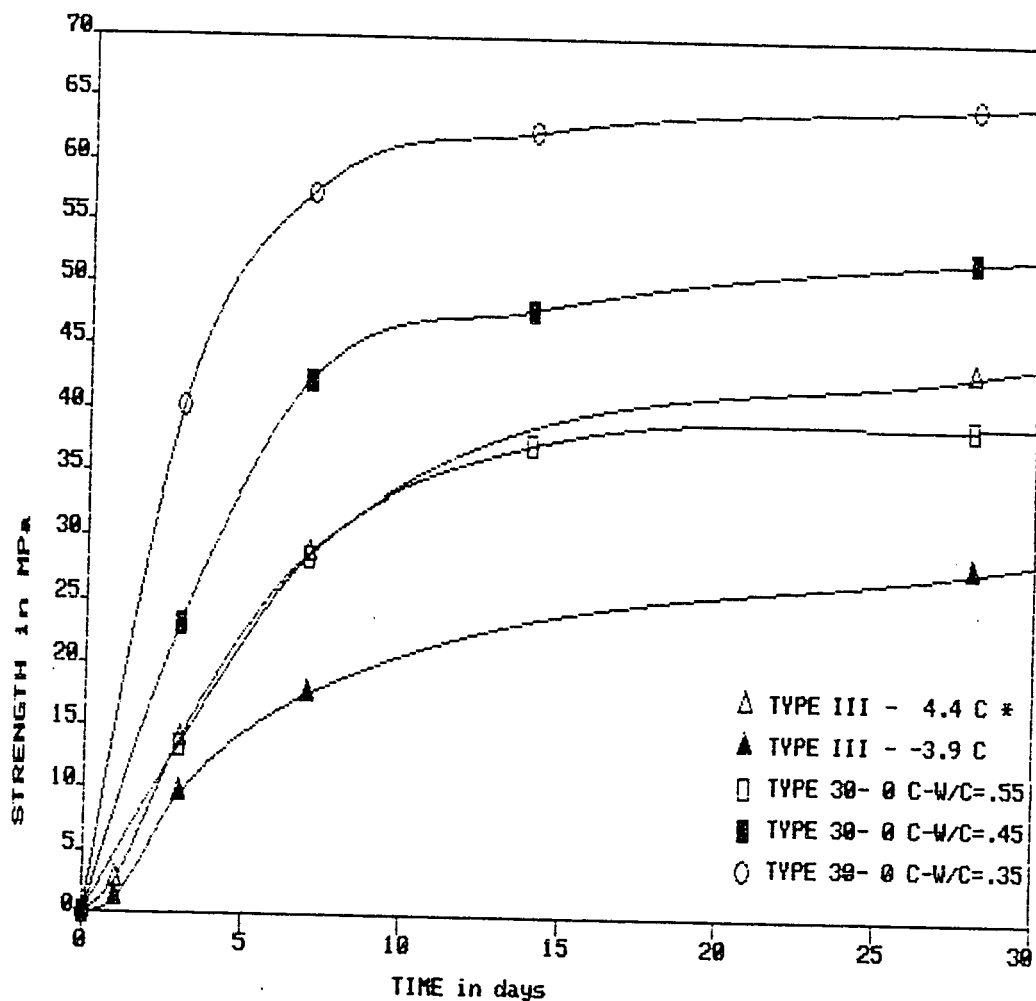


Fig. 3-24 Comparison between Klieger results of concrete compressive strength -using ASTM type III cement and cured at 4.4 and -3.9 degree Celsius-, and Gardner and Sau results -using CSA type 30 cement and cured at 0 degree Celsius. (data for a period of 30 days only, refer to Tables 1-4 and 3-1).

- \* Curing temperature in degree Celsius.
- These curves were plotted by using smooth curve fit between the points-.

Fig 3-25 Plot of equation 3-4

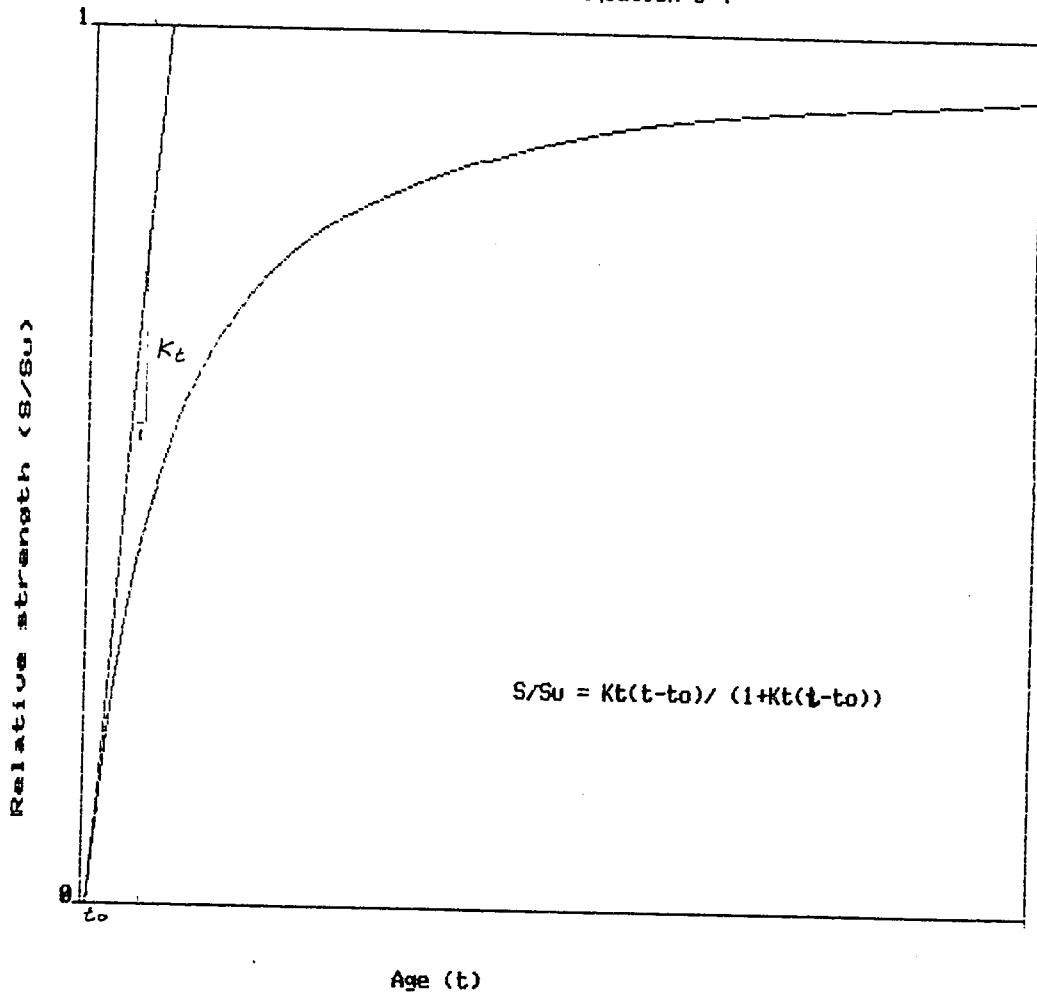


Fig. 3-26 Plot of equation 3-7.

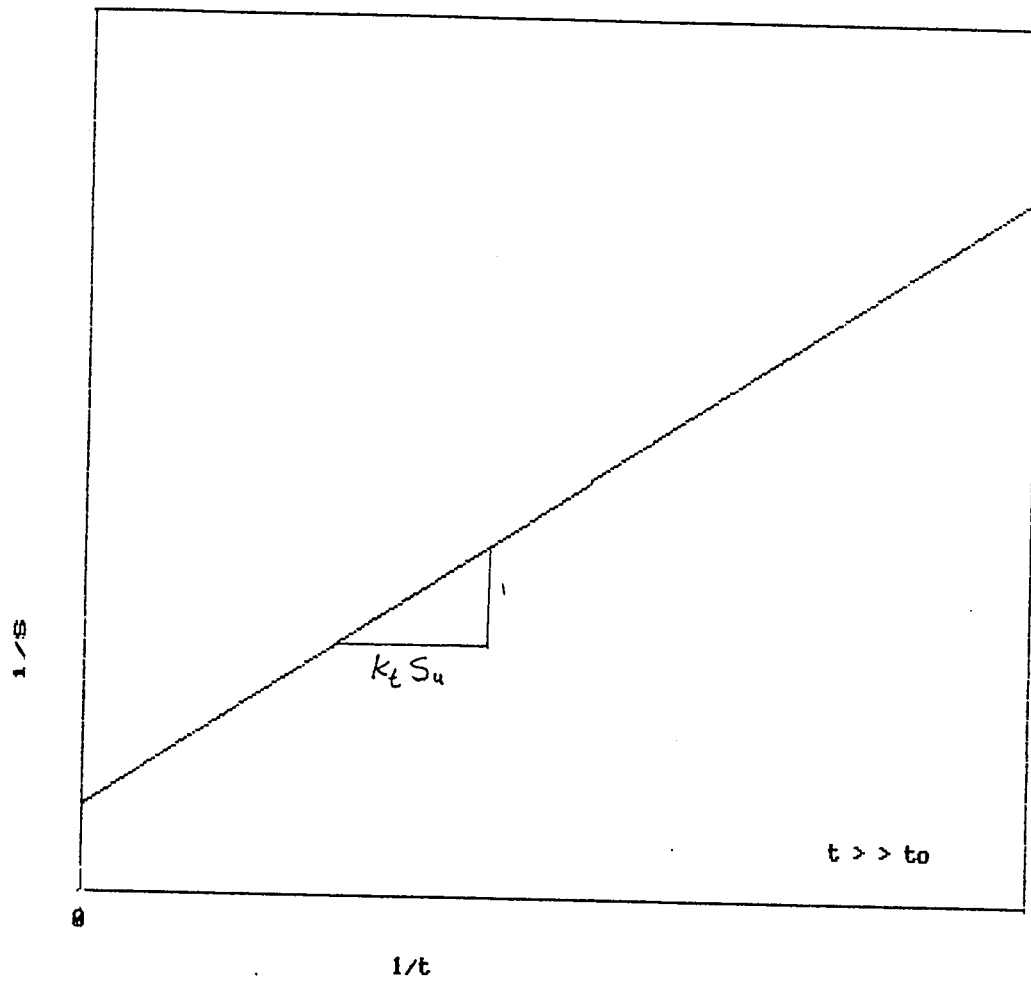
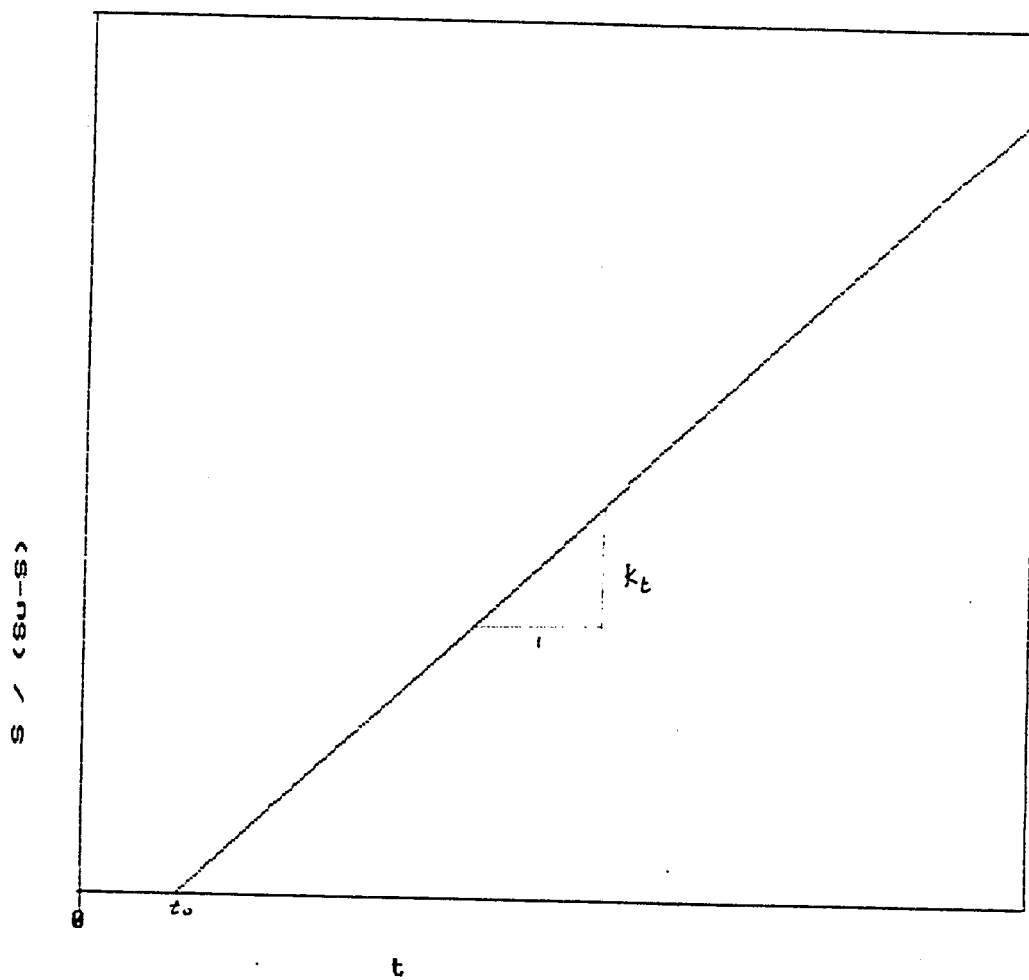


Fig 3-27 Plot of equation 3-8



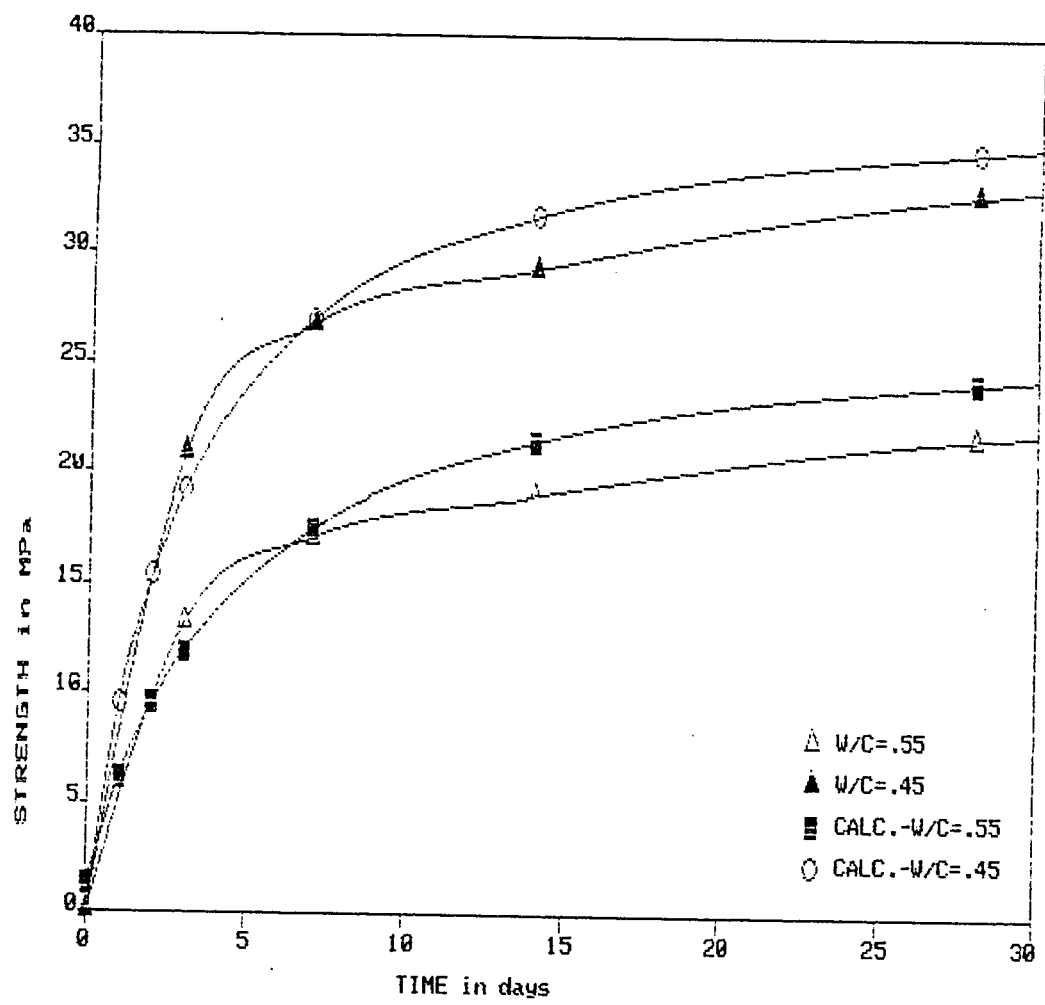


Fig. 3-28 Comparison between experimental and calculated results of the compressive strength of concrete based on Gardner and Sau data using CSA type 10 cement and cured at 45 degree Celsius (data for a period of 30 days only).

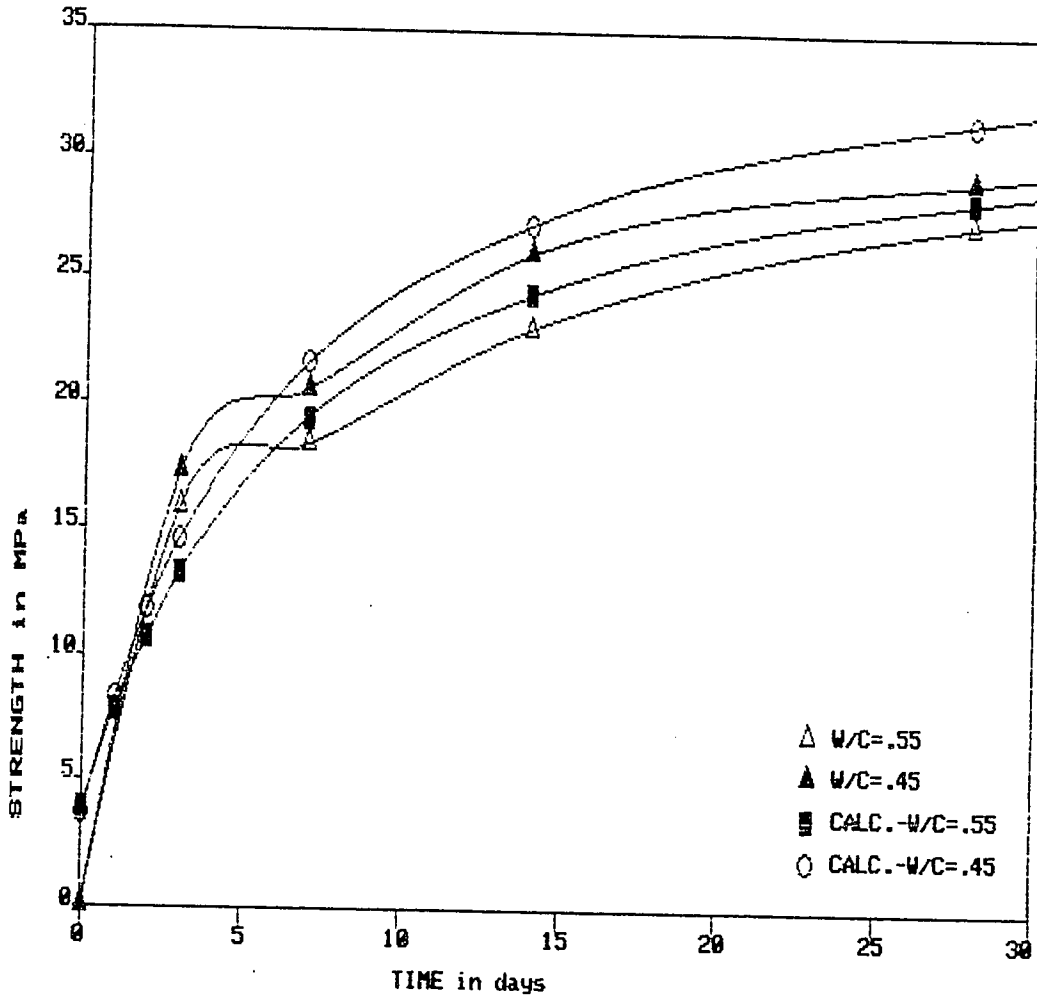


Fig. 3-29 Comparison between experimental and calculated results of the compressive strength of concrete based on Gardner and Sau data using CSA type 10 cement and cured at 16 degree Celsius (data for a period of 30 days only).

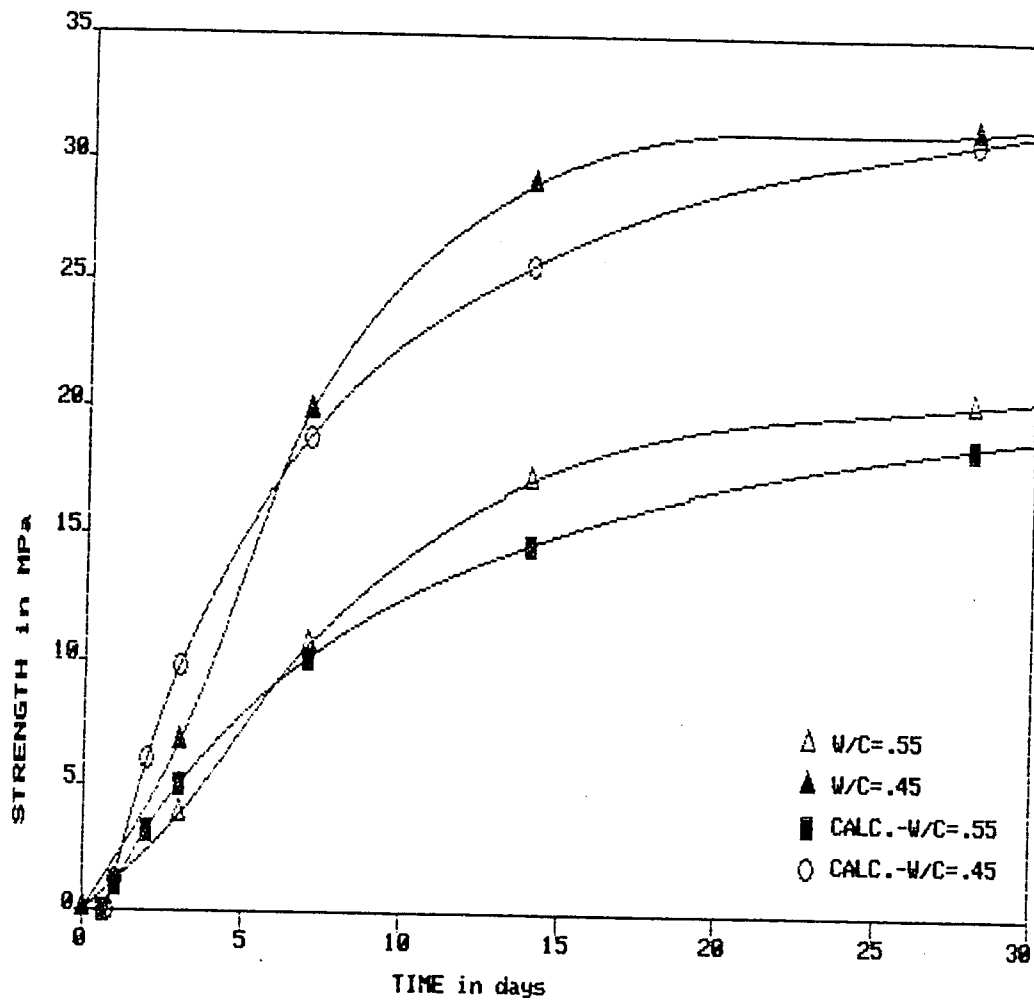


Fig. 3-30 Comparison between experimental and calculated results of the compressive strength of concrete based on Gardner and Sau data using CSA type 10 cement and cured at 0 degree Celsius (data for a period of 30 days only).

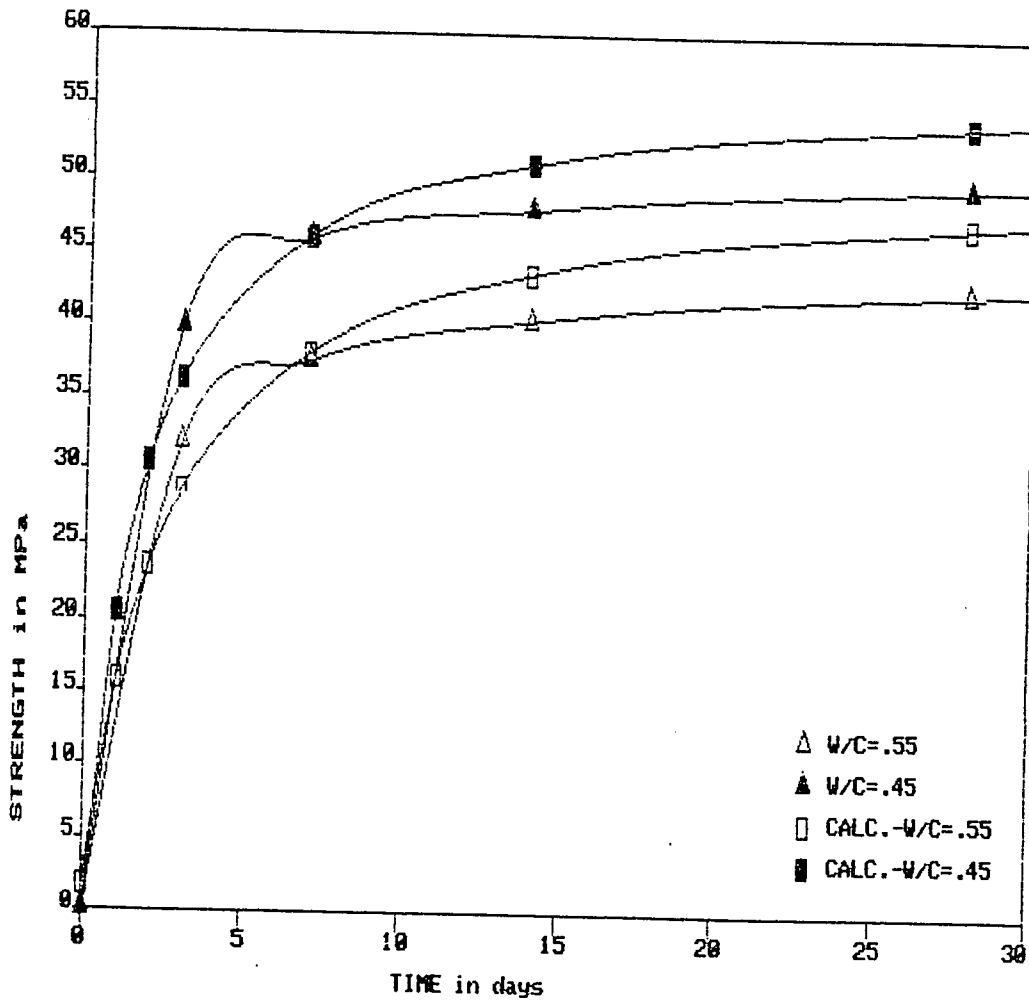


Fig. 3-31 Comparison between experimental and calculated results of the compressive strength of concrete based on Gardner and Sau data using CSA type 30 cement and cured at 22 degree Celsius (data for a period of 30 days only).

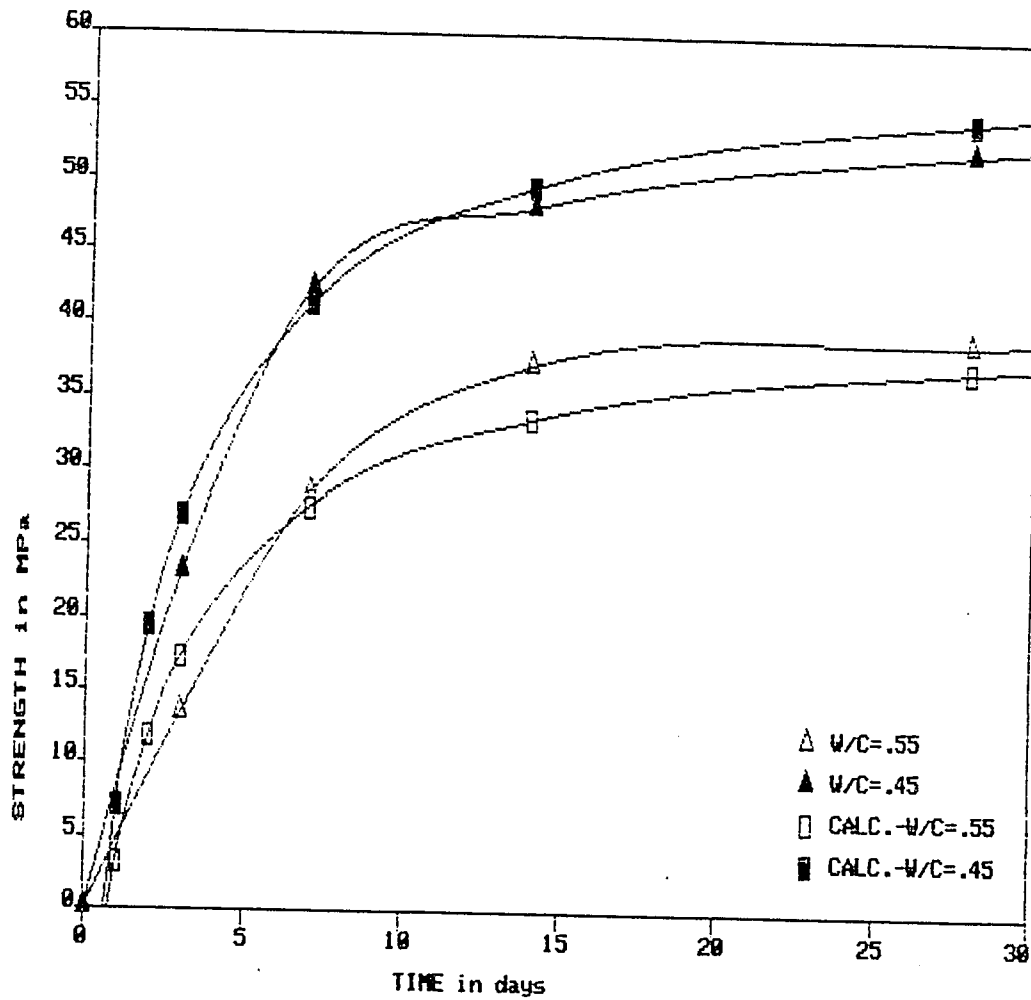


Fig. 3-32 Comparison between experimental and calculated results of the compressive strength of concrete based on Gardner and Sau data using CSA type 30 cement and cured at 0 degree Celsius (data for a period of 30 days only).



Fig. 3-33 Comparison between experimental and calculated results of the compressive strength of concrete based on Klieger data using ASTM type I cement and cured at 48.9 degree Celsius (data for a period of 30 days only).

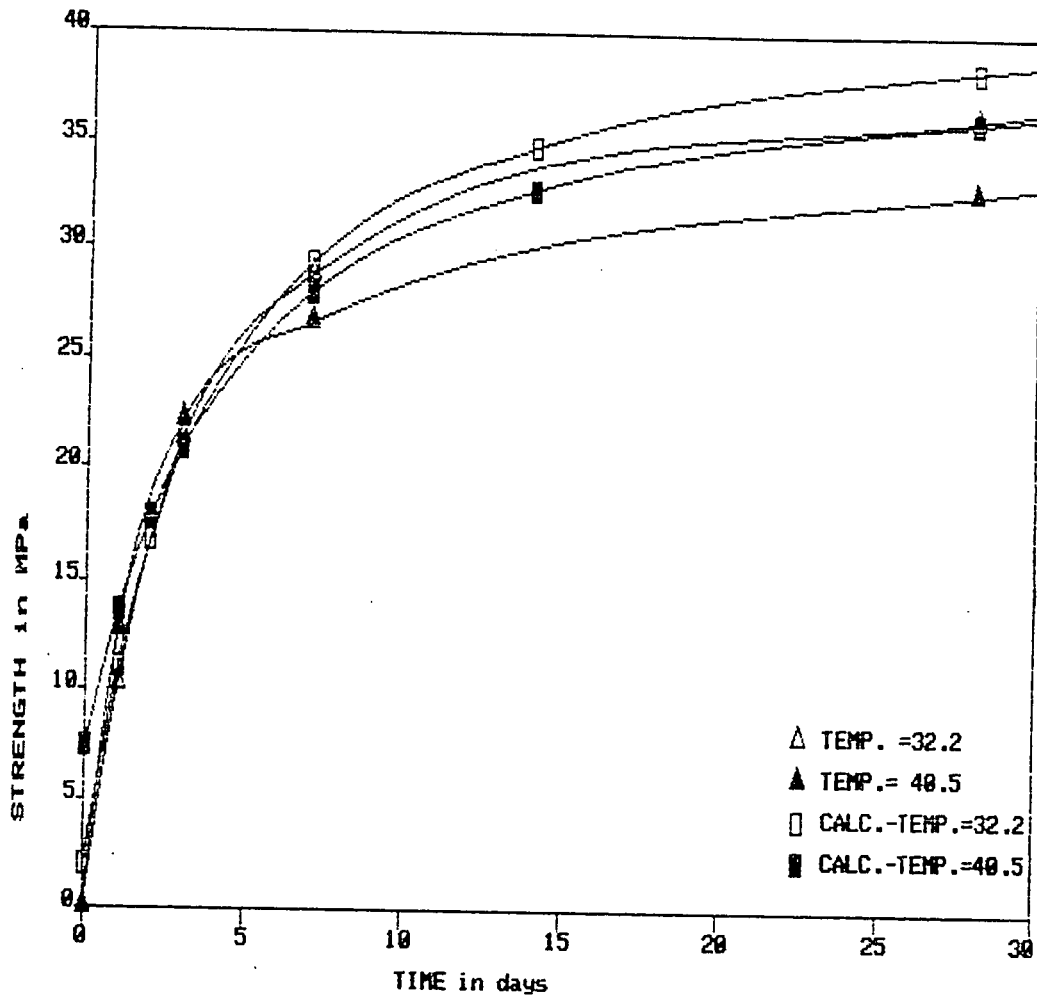


Fig. 3-34 Comparison between experimental and calculated results of the compressive strength of concrete based on Klieger data using ASIM type I cement and cured at 40.5 and 32.2 degree Celsius (data for a period of 30 days only).

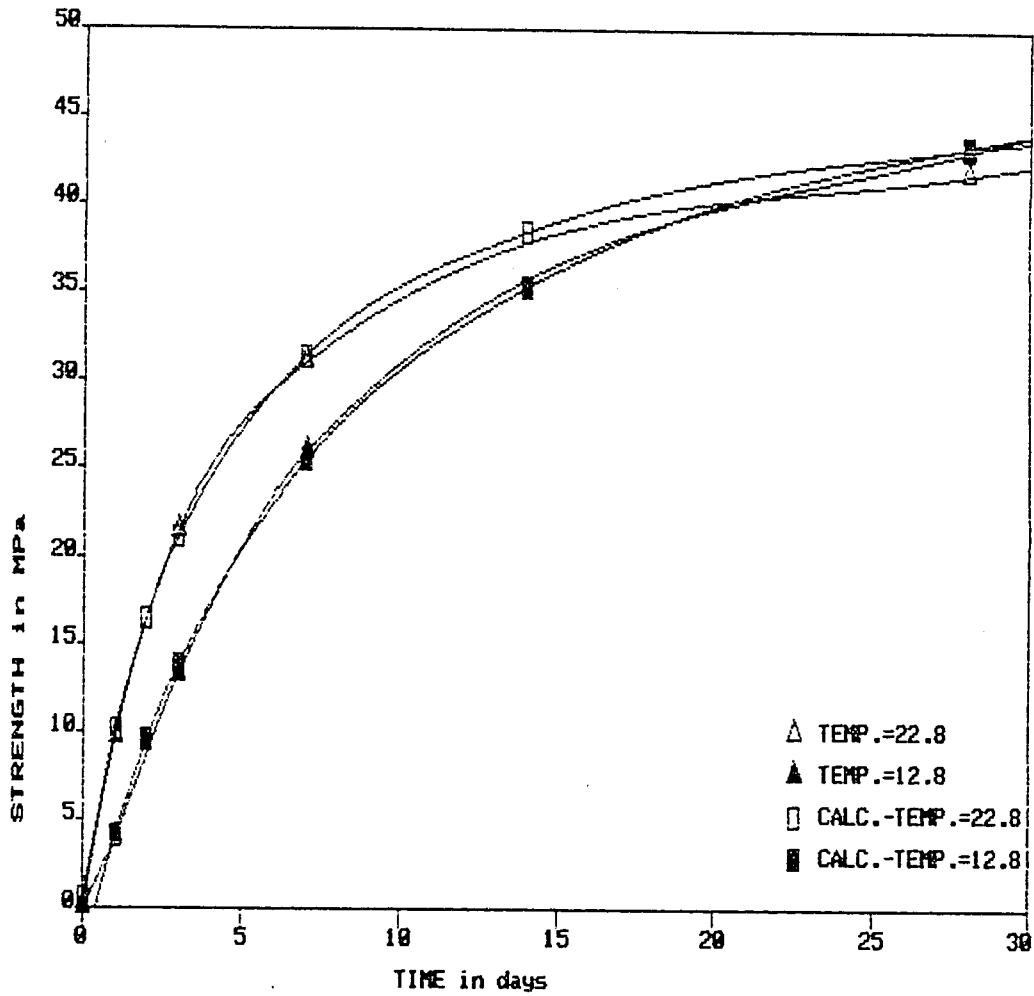


Fig. 3-35 Comparison between experimental and calculated results of the compressive strength of concrete based on Klieger data using ASTM type I cement and cured at 22.8 and 12.8 degree Celsius (data for a period of 30 days only).

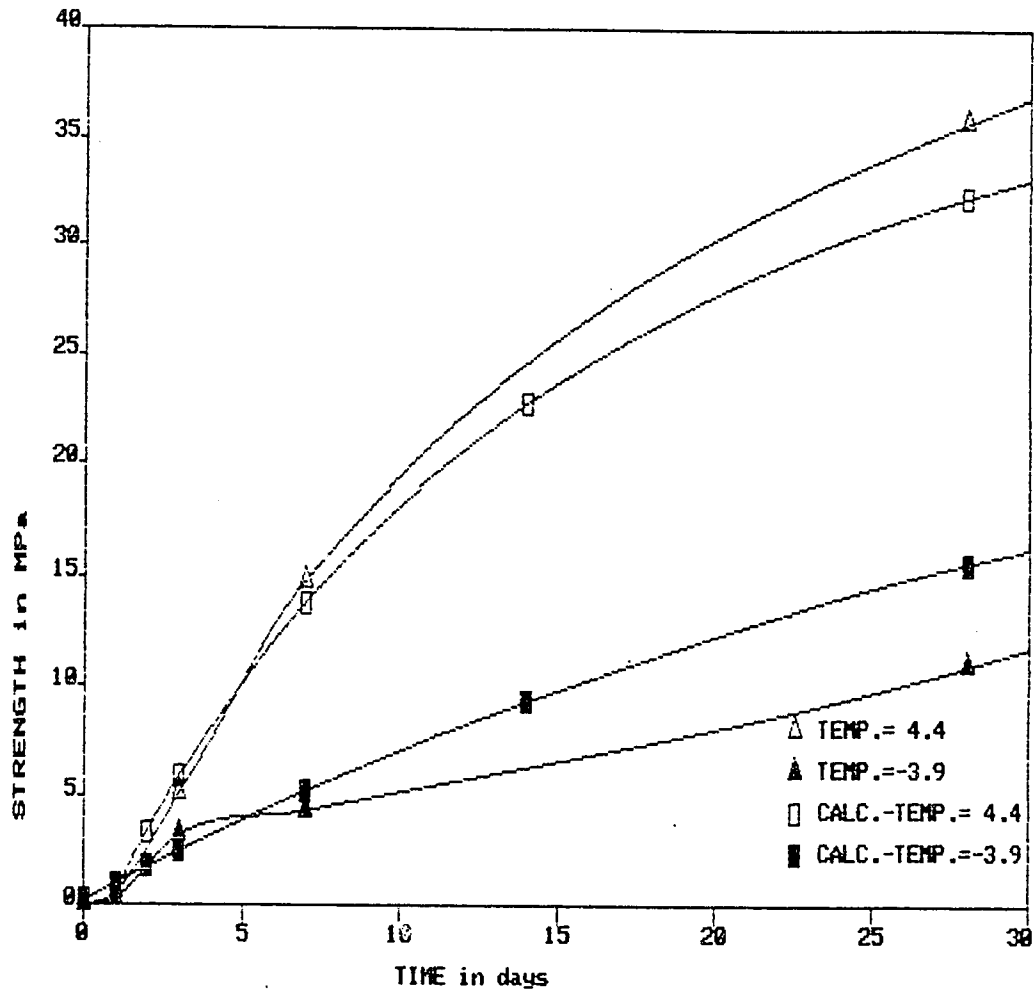


Fig. 3-36 Comparison between experimental and calculated results of the compressive strength of concrete based on Klieger data using ASTM type I cement and cured at 4.4 and -3.9 degree Celsius (data for a period of 30 days only).

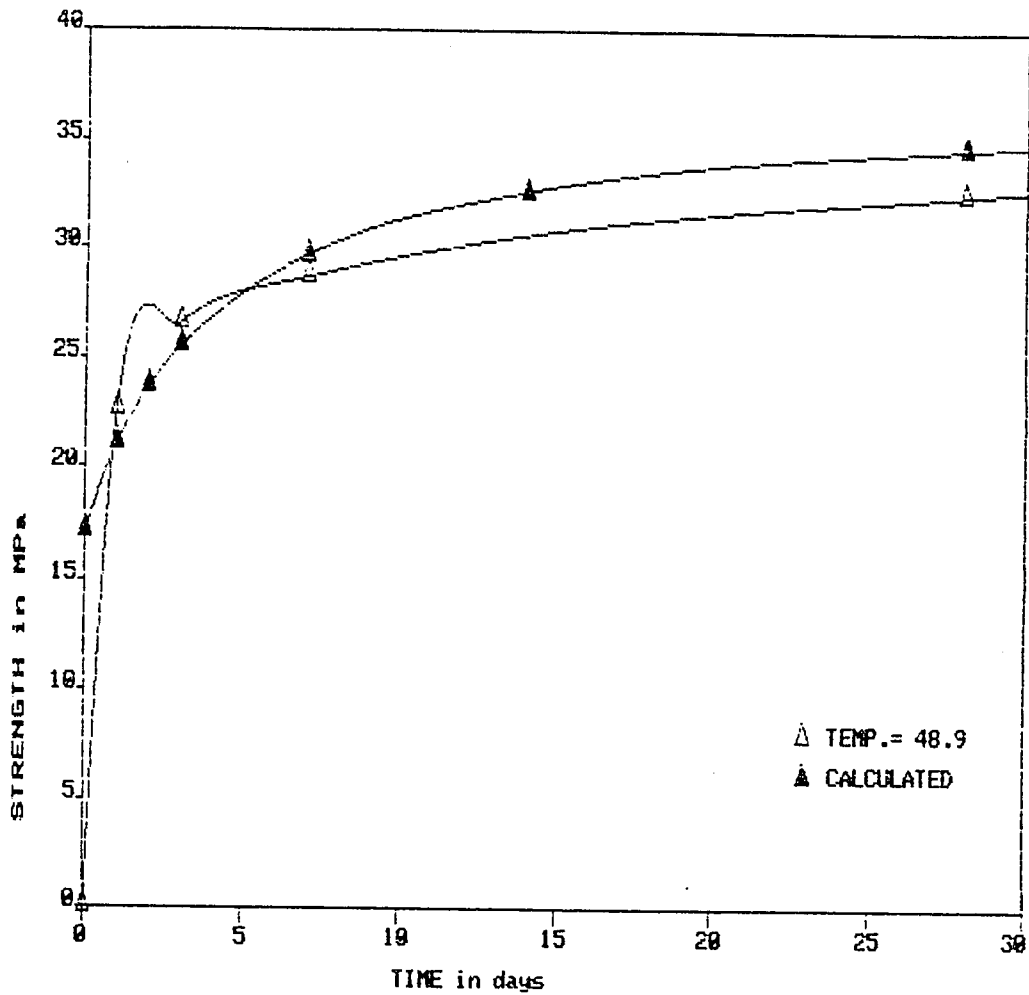


Fig. 3-37 Comparison between experimental and calculated results of the compressive strength of concrete based on Klieger data using ASTM type III cement and cured at 48.9 degree Celsius (data for a period of 30 days only).

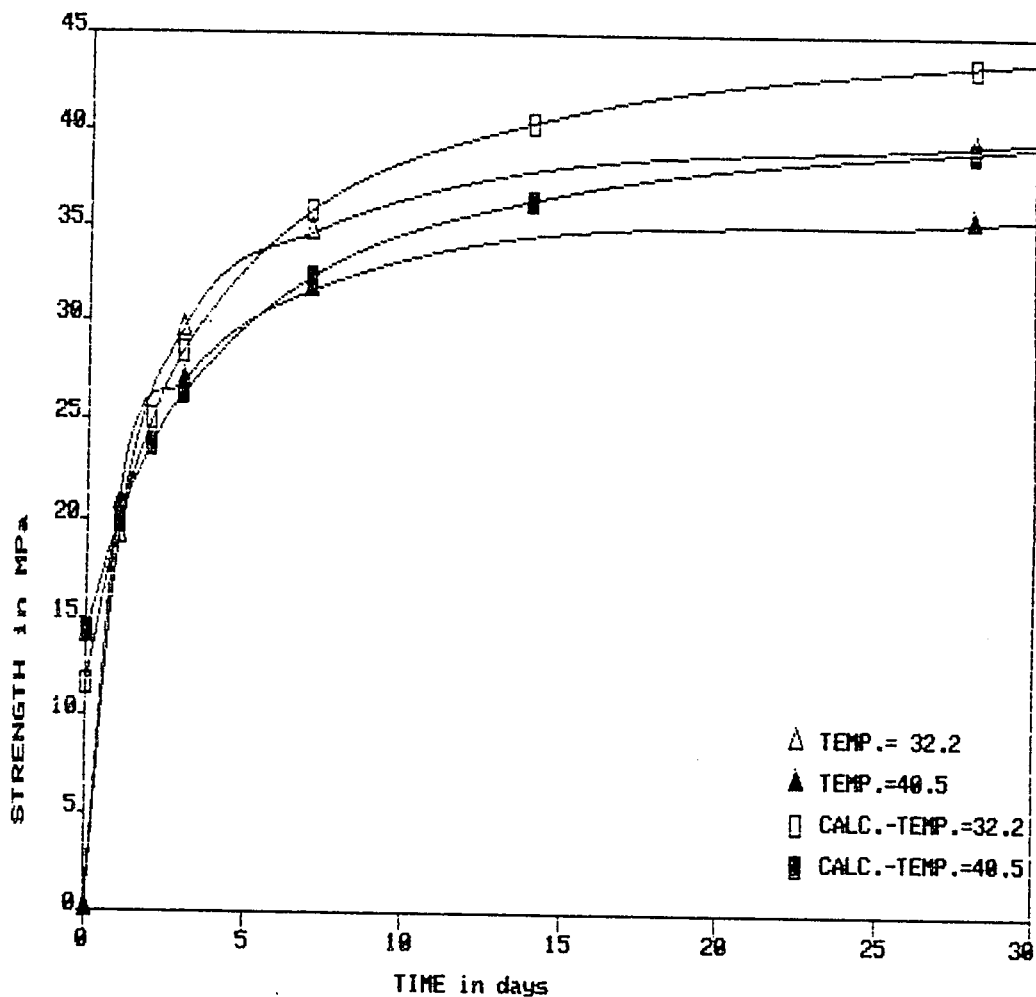


Fig. 3-38 Comparison between experimental and calculated results of the compressive strength of concrete based on Klieger data using ASTM type III cement and cured at 40.5 and 32.2 degree Celsius (data for a period of 30 days only).

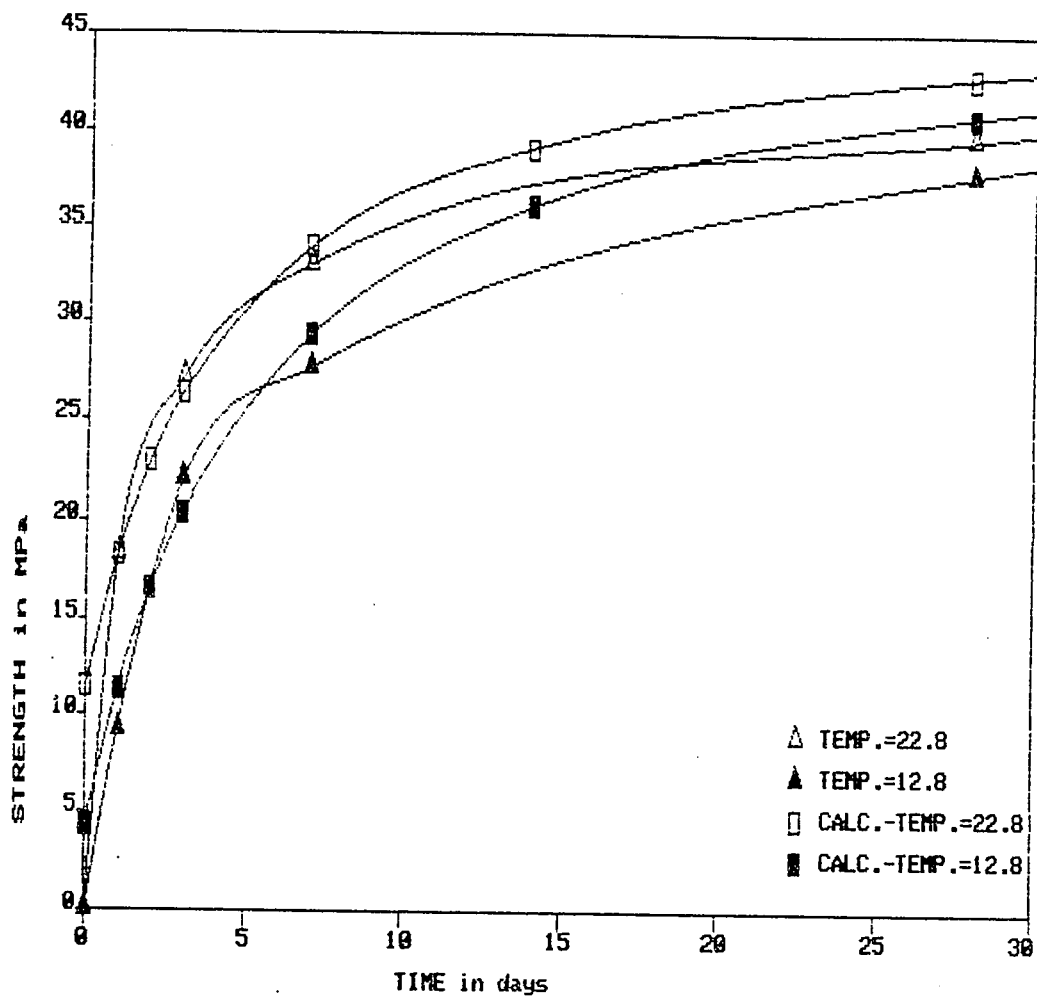


Fig. 3-39 Comparison between experimental and calculated results of the compressive strength of concrete based on Klieger data using ASTM type III cement and cured at 22.8 and 12.8 degree Celsius (data for a period of 30 days only).

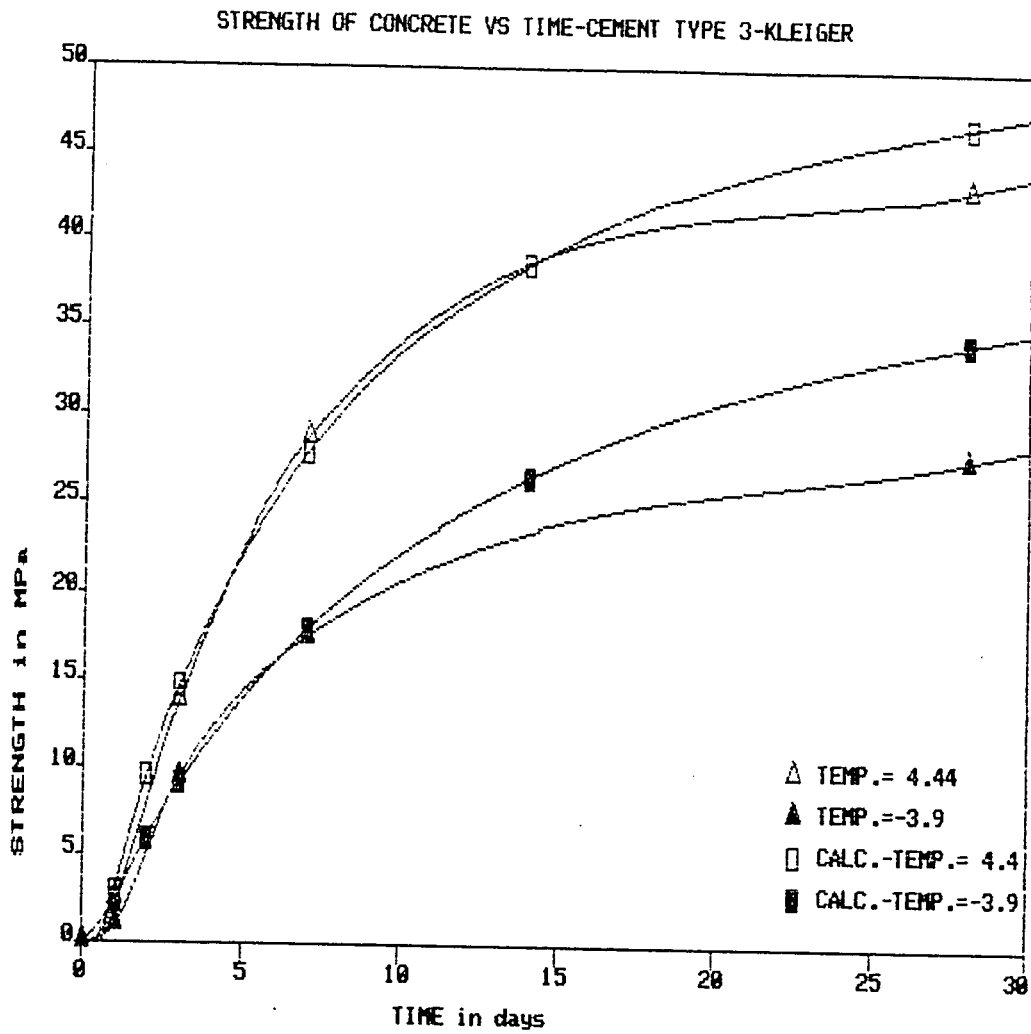


Fig. 3-40 Comparison between experimental and calculated results of the compressive strength of concrete based on Klieger data using ASTM type III cement and cured at 4.4 and -3.9 degree Celsius (data for a period of 30 days only).

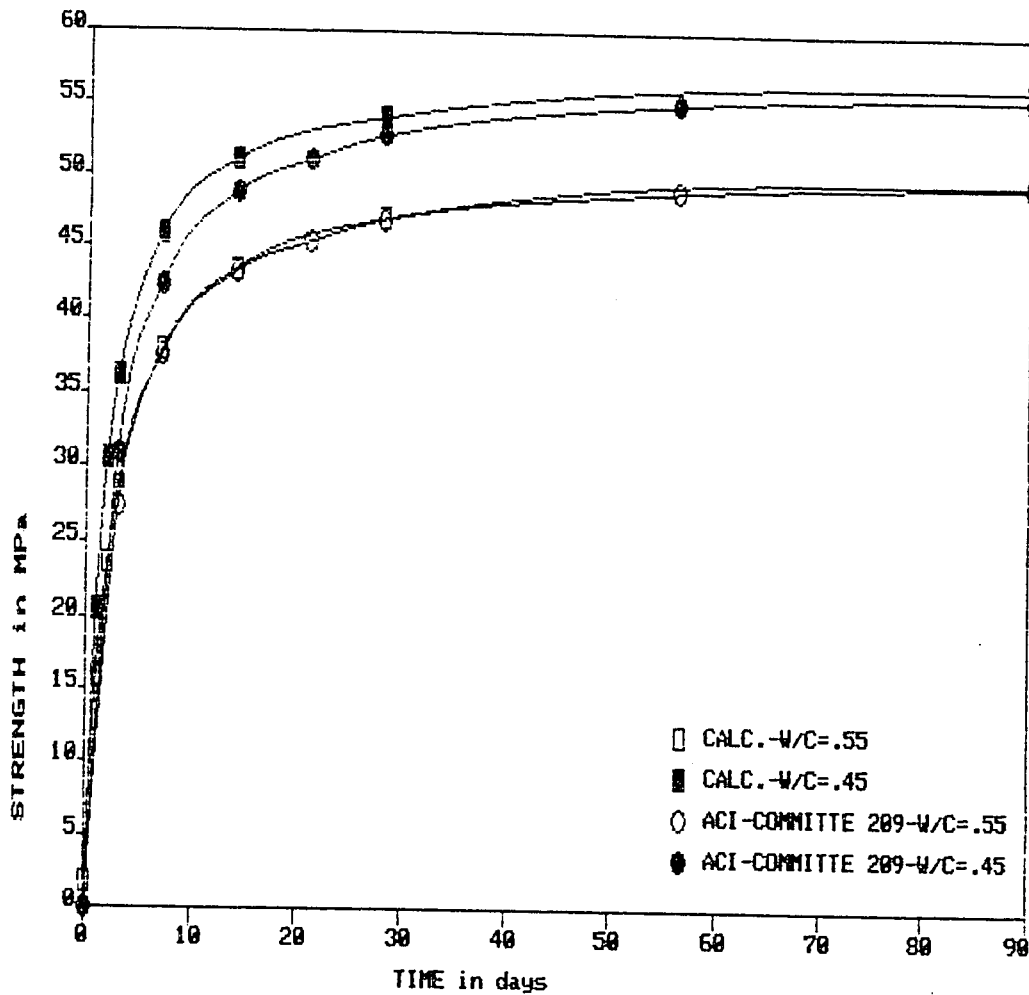


Fig. 3-41 Comparison between the calculated and the ACI- Committee 209 compressive strength of concrete results based on Gardner and Sau data using CSA type 30 cement cured at 22 degree Celsius.

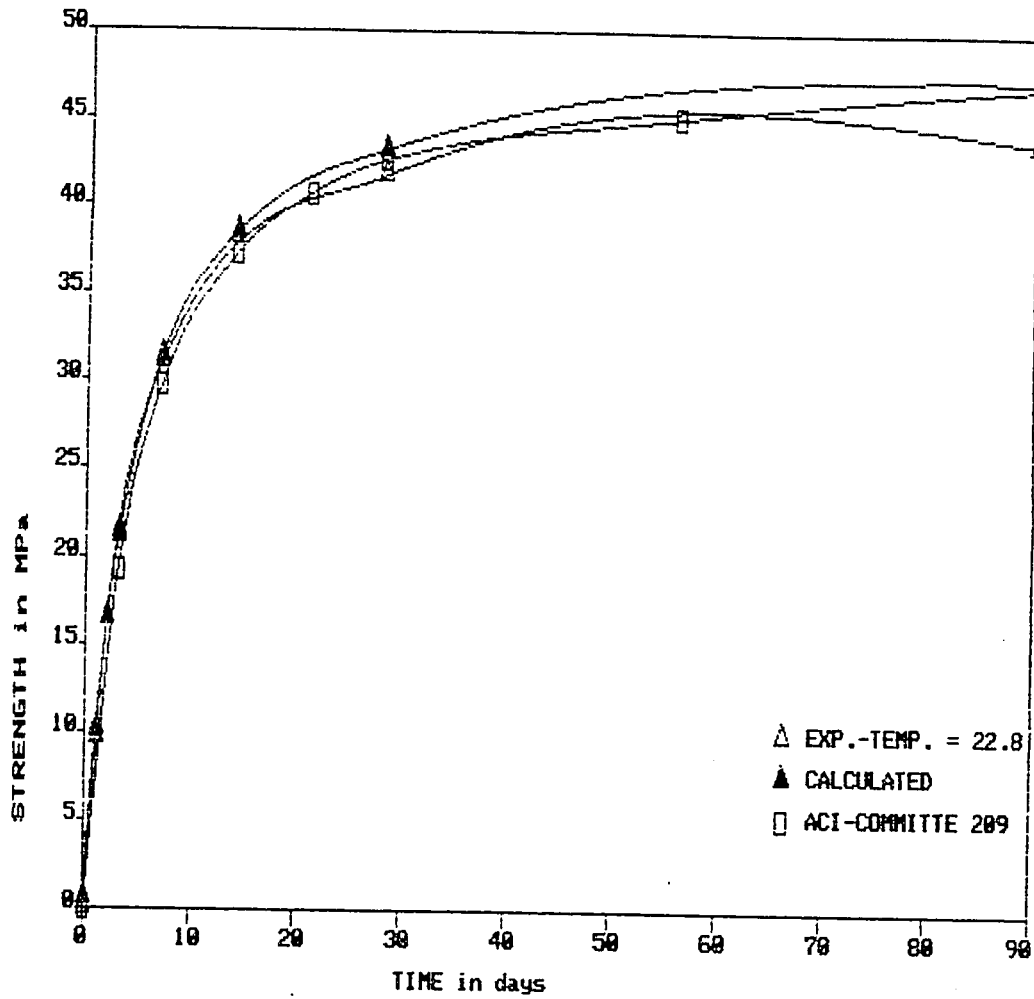


Fig. 3-42 Comparison between the calculated and the ACI- Committee 209 compressive strength of concrete results based on Klieger data using ASTM type I cement cured at 22 degree Celsius.

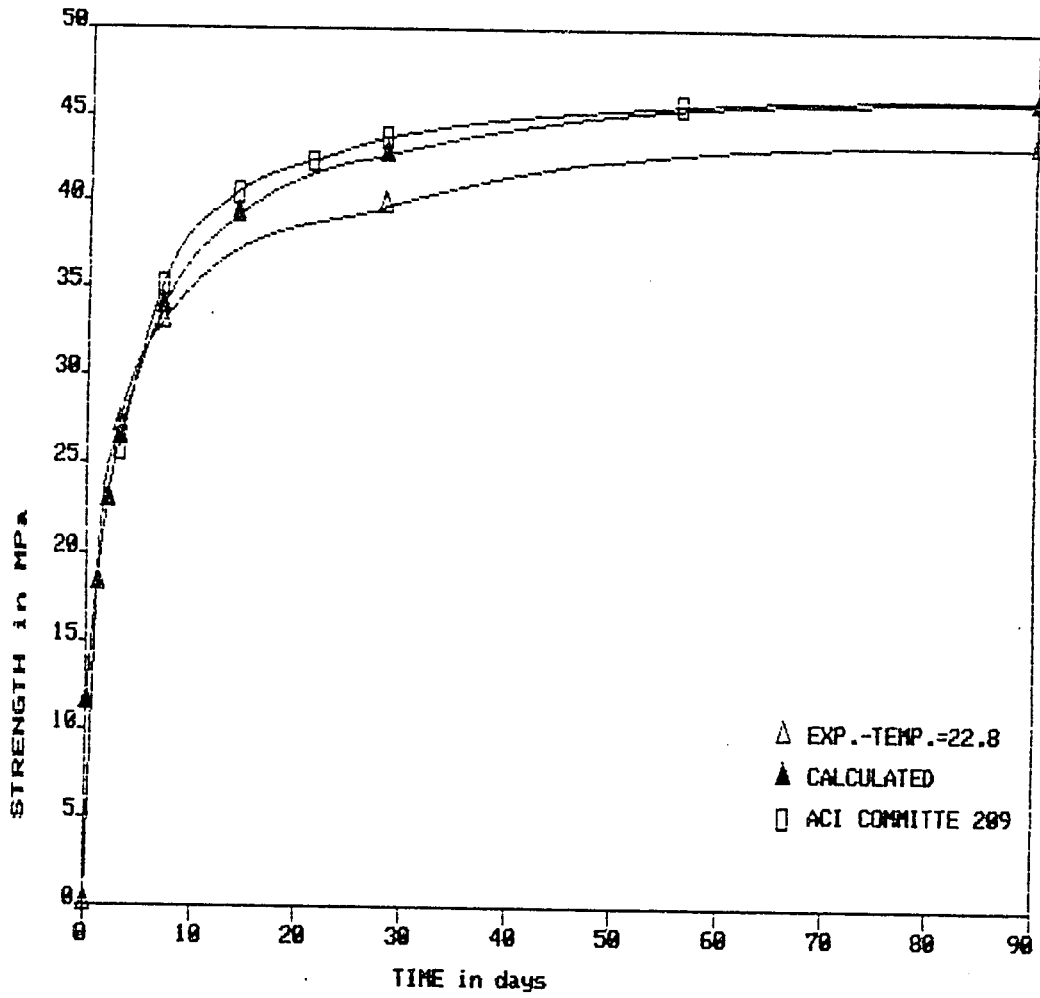


Fig. 3-43 Comparison between the calculated and the ACI- Committee 209 compressive strength of concrete results based on Klieger data using ASTM type III cement cured at 22 degree Celsius.

FIG. 3-44 RATE CONSTANT VS CURING TEMP. - KLIEGER

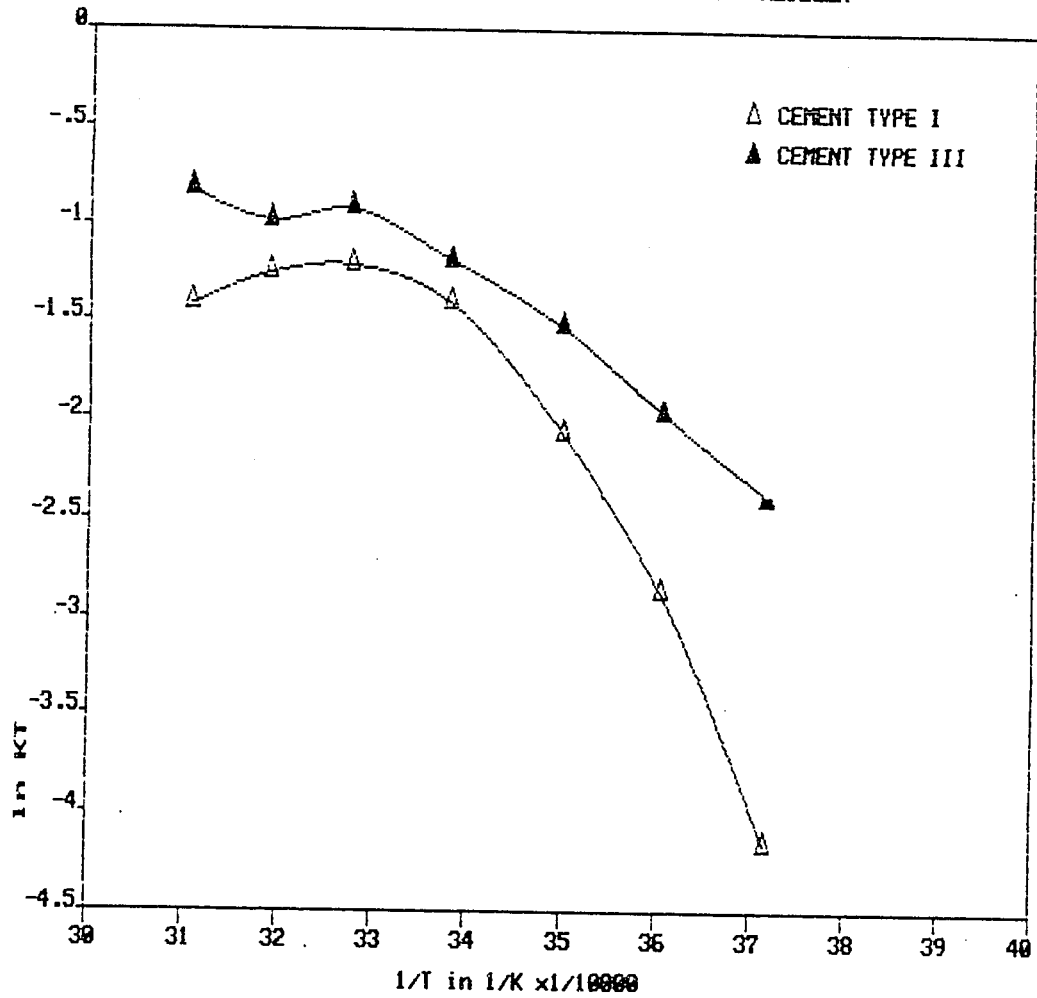


FIG. 3-45 RATE CONSTANT VS CURING TEMP. - KLIEGER

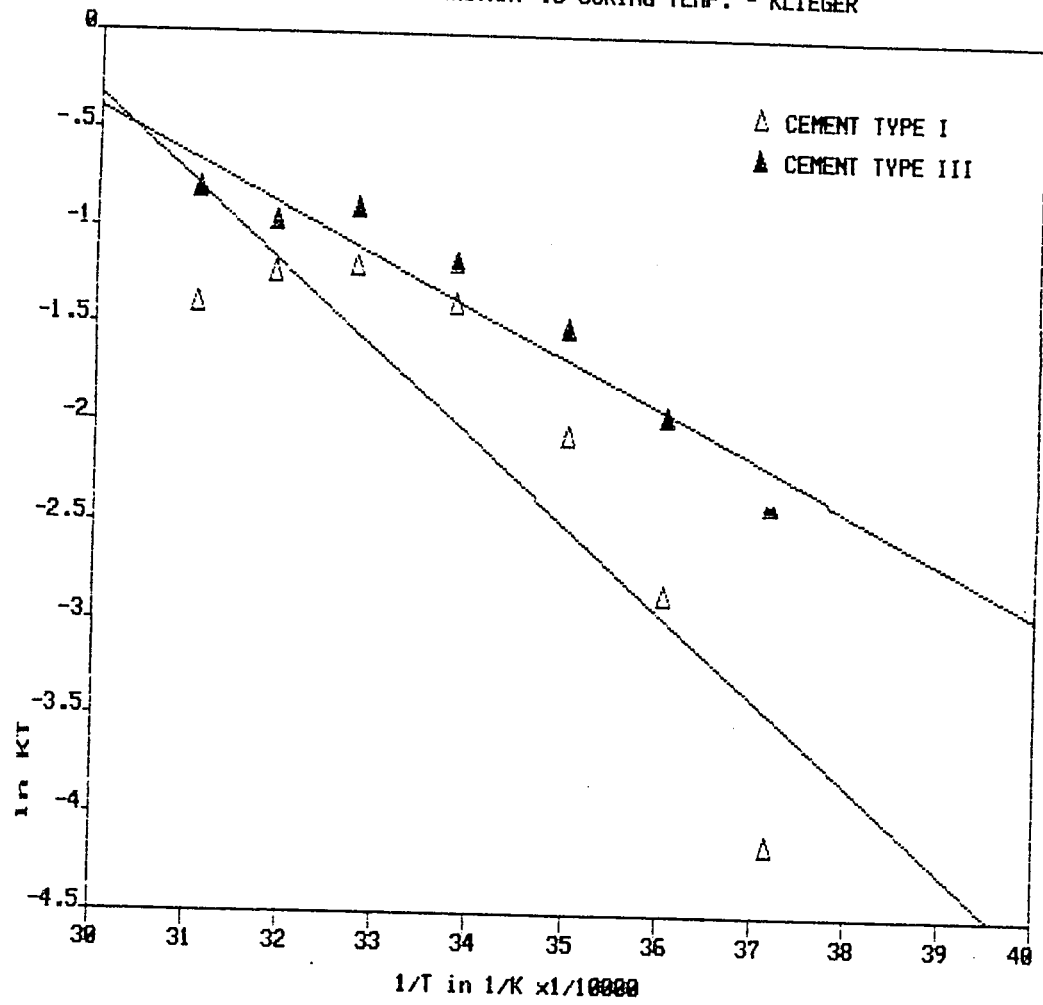


FIG. 3-46 RATE CONSTANT VERSUS CURING TEMPERATURE

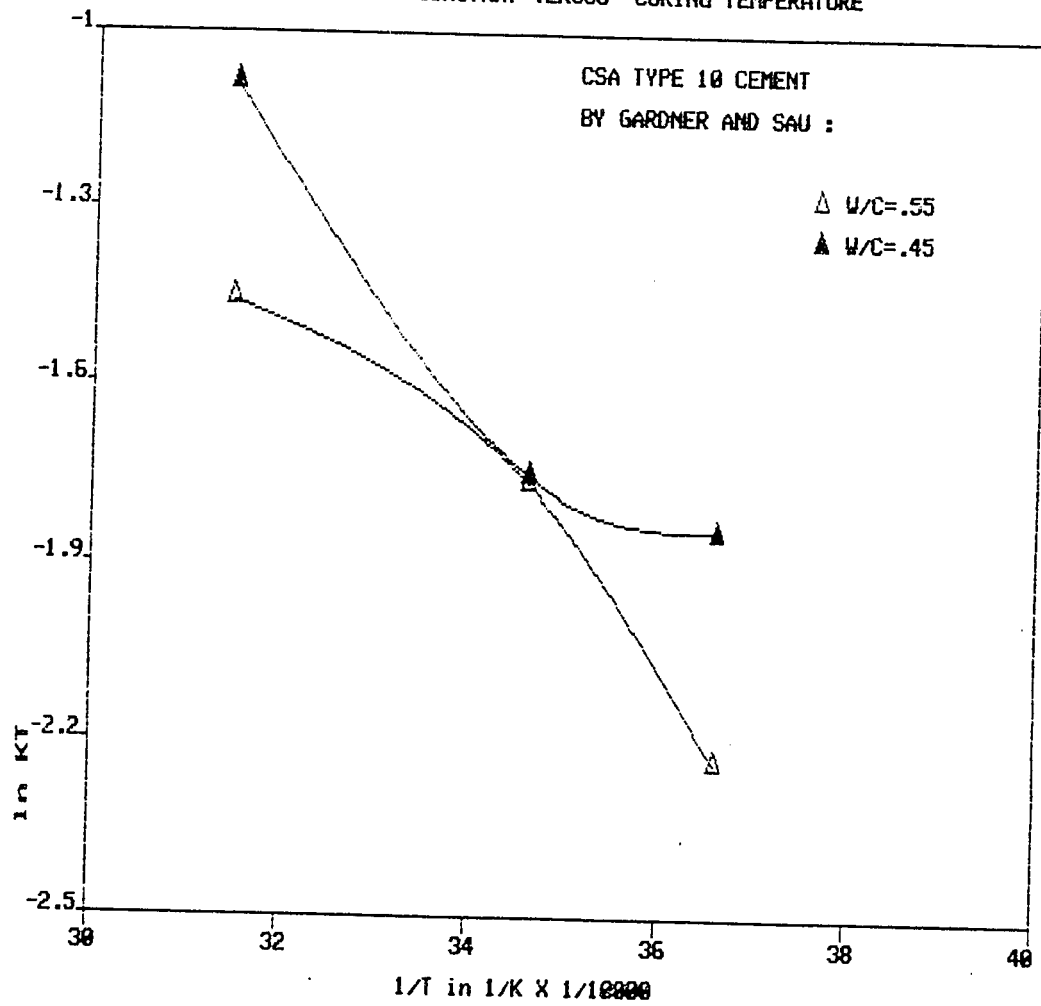
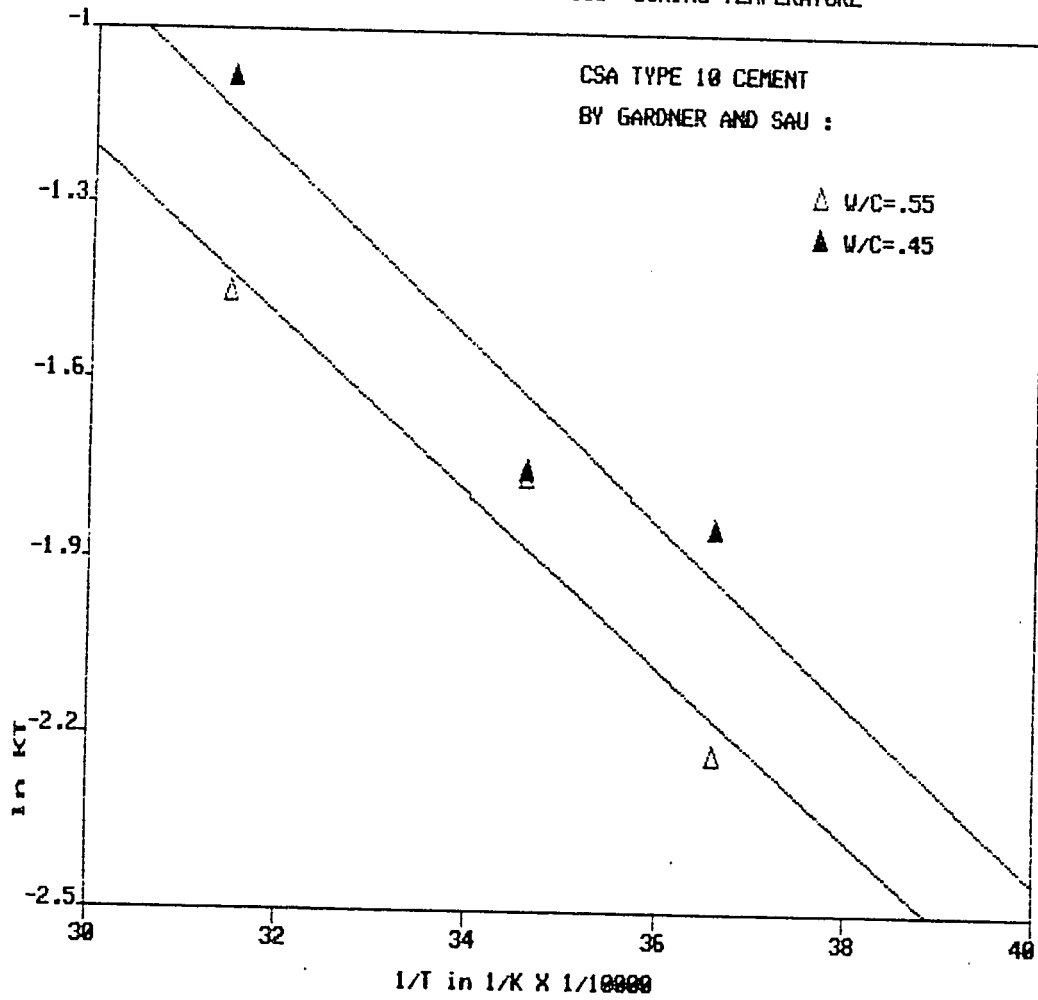


FIG. 3-47 RATE CONSTANT VERSUS CURING TEMPERATURE



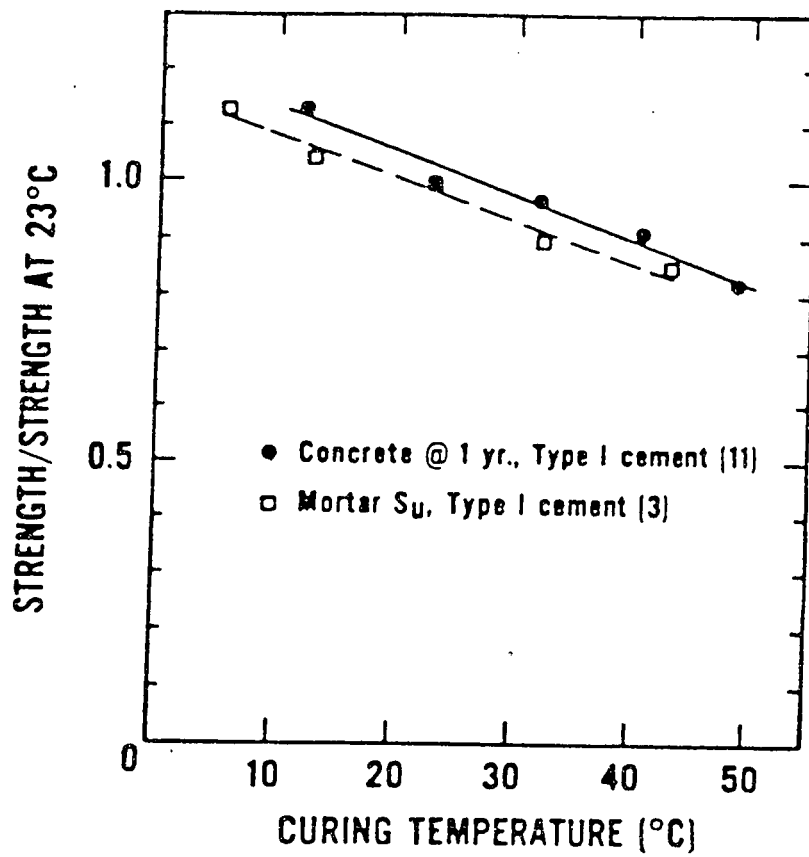


Fig. 3-48 Effect of initial curing temperature on strength at later ages. (18)

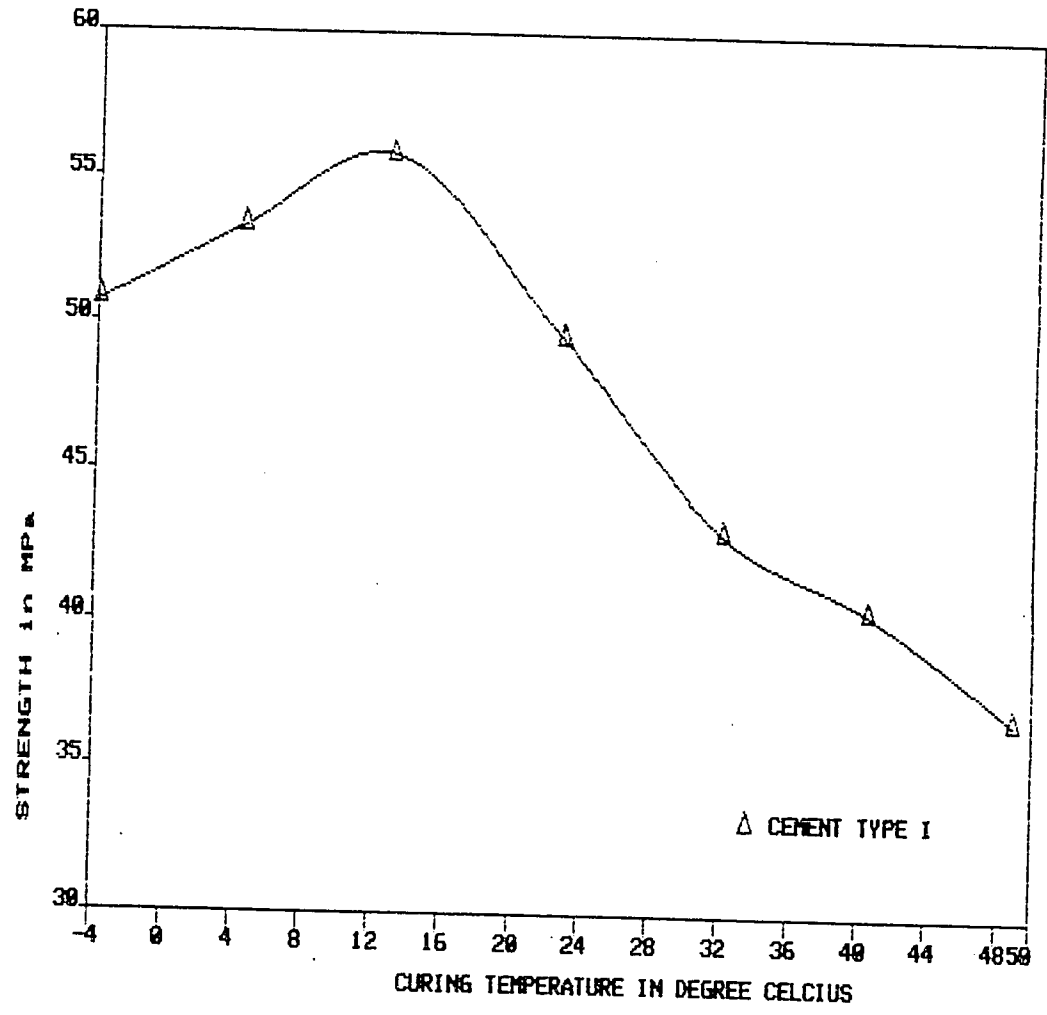


Fig. 3-49 Effect of initial curing temperature on strength at 1 year-age - Klieger results, using ASTM type I cement concrete (smooth curve fit).

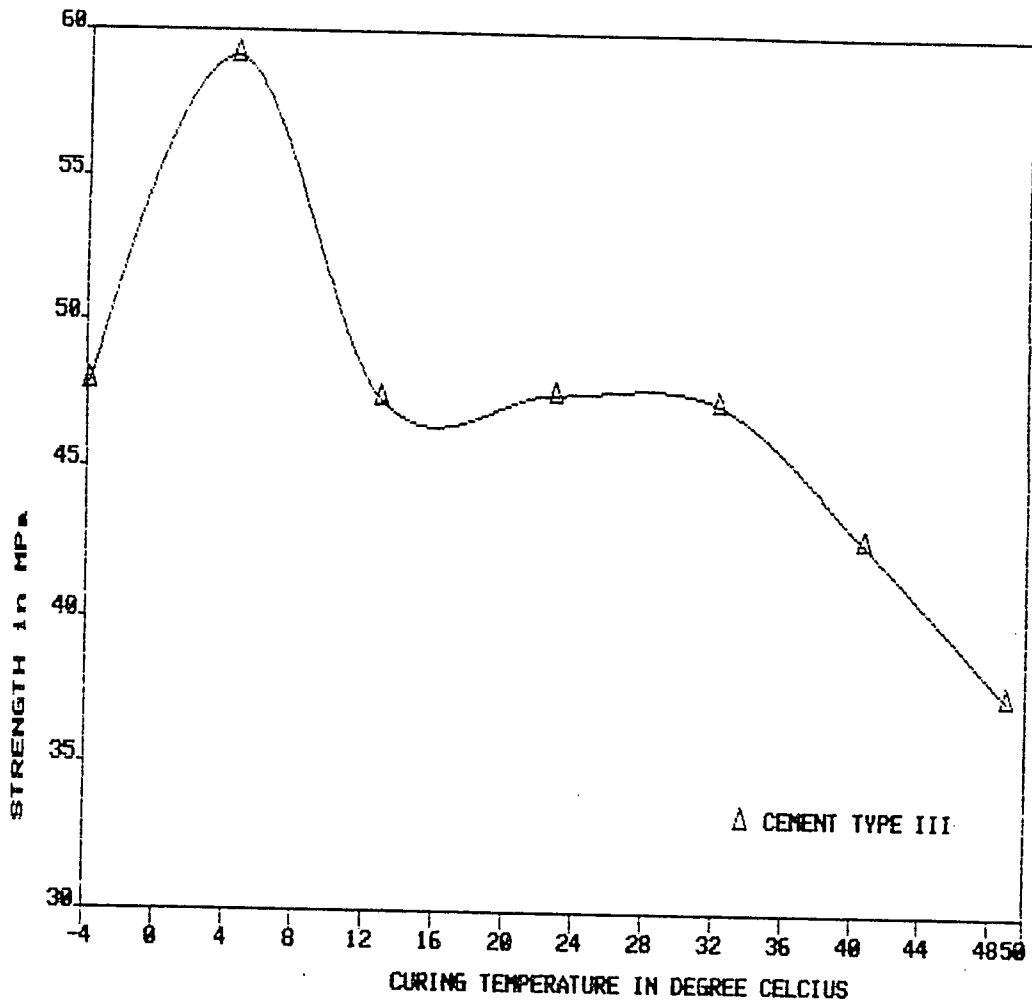


Fig. 3-50 Effect of initial curing temperature on strength at 1 year-age - Klieger results, using ASTM type III cement concrete (smooth curve fit).

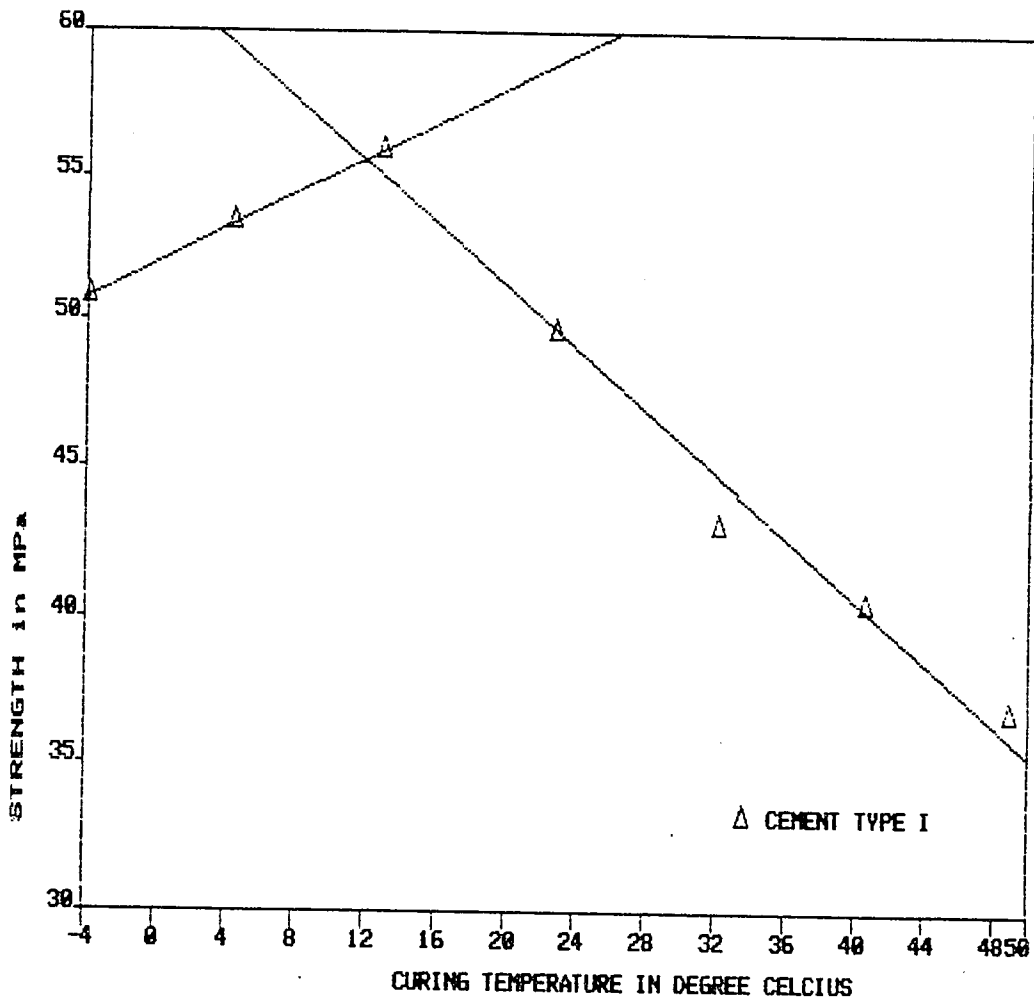


Fig. 3-51 Effect of initial curing temperature on strength at 1 year-age - Klieger results, using ASTM type I cement concrete (straight line fit).

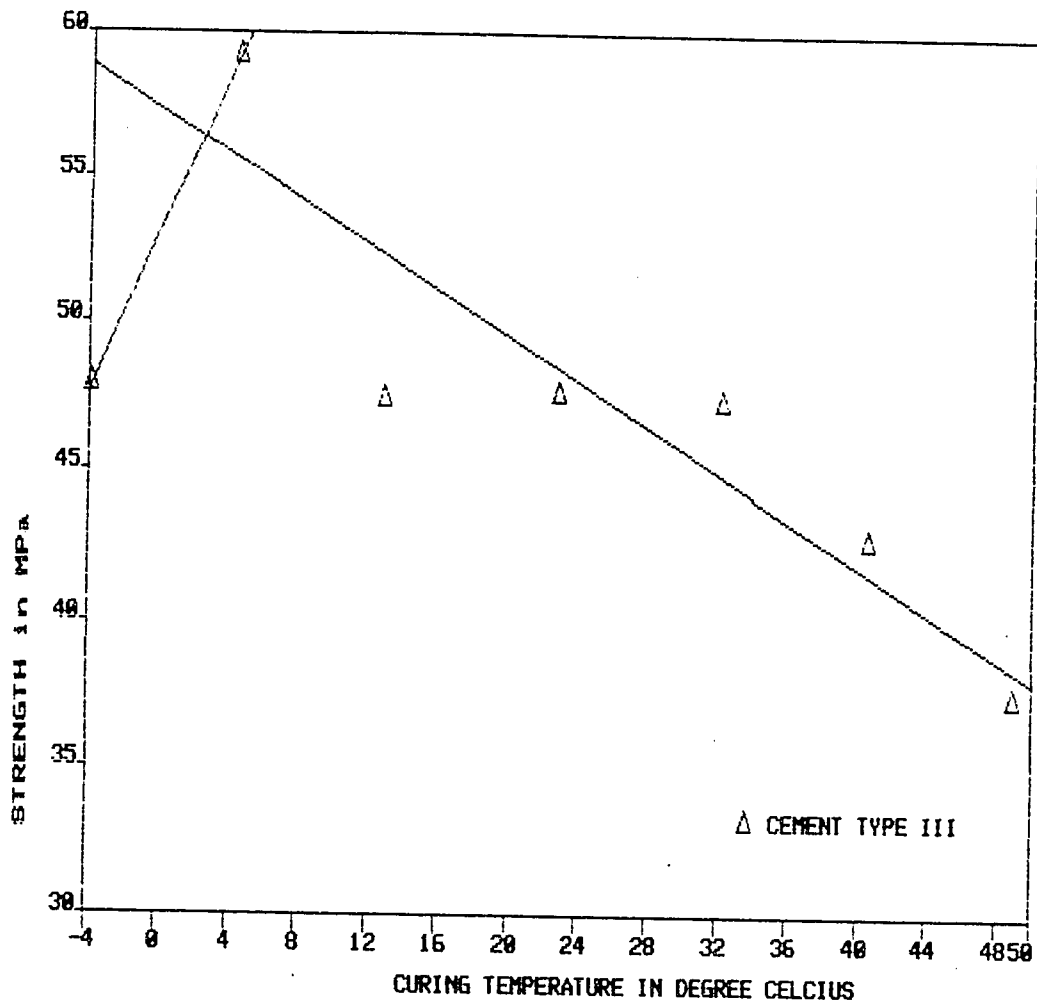


Fig. 3-52 Effect of initial curing temperature on strength at 1 year-age - Klieger results, using ASTM type III cement concrete (straight line fit).

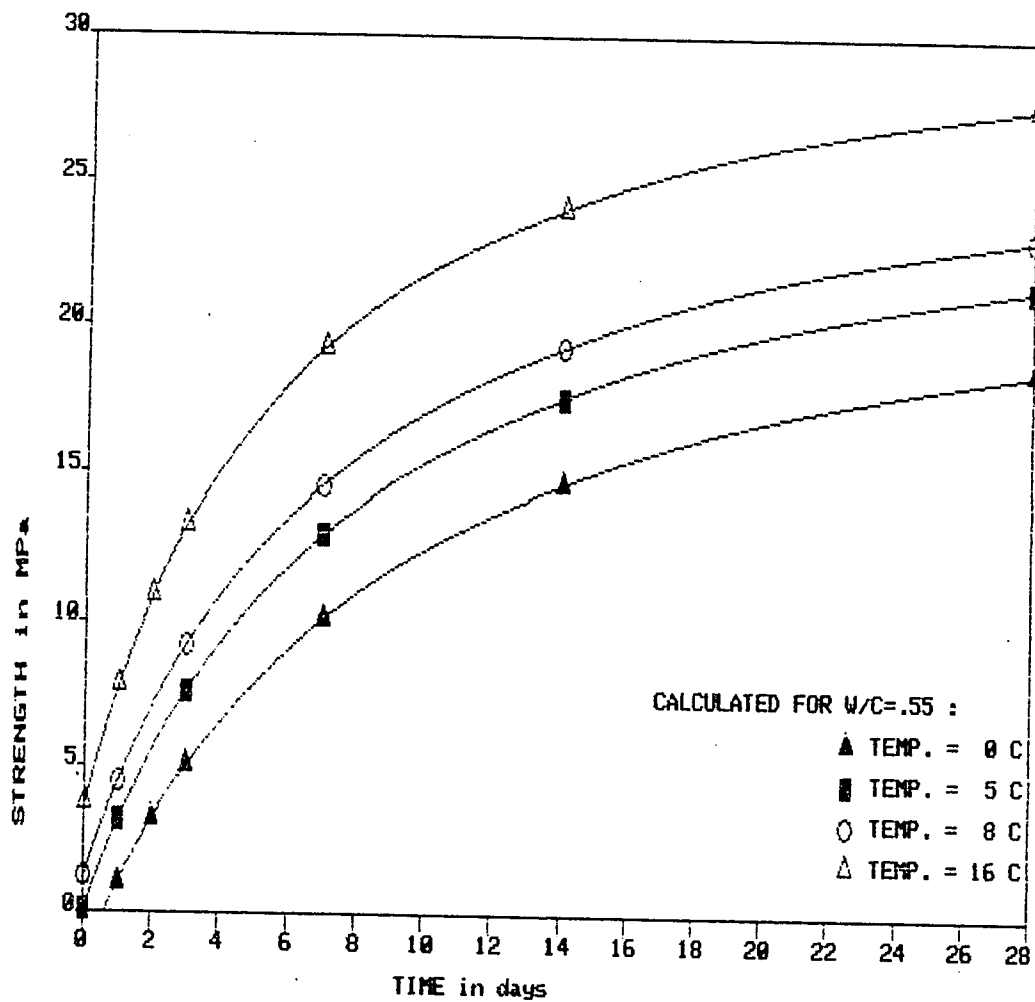


Fig. 3-53 Plots of the compressive strength development equations used in the computer program for CSA type 10 cement concrete.

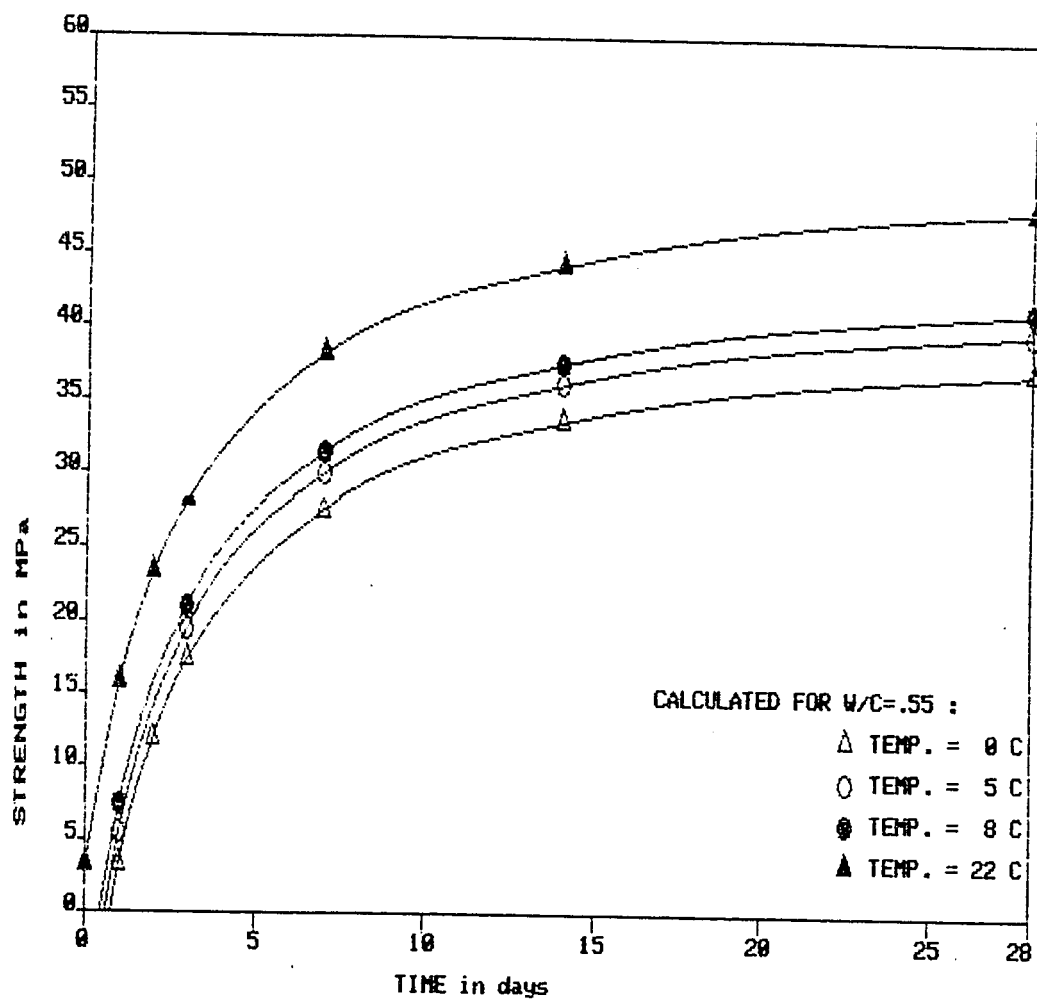
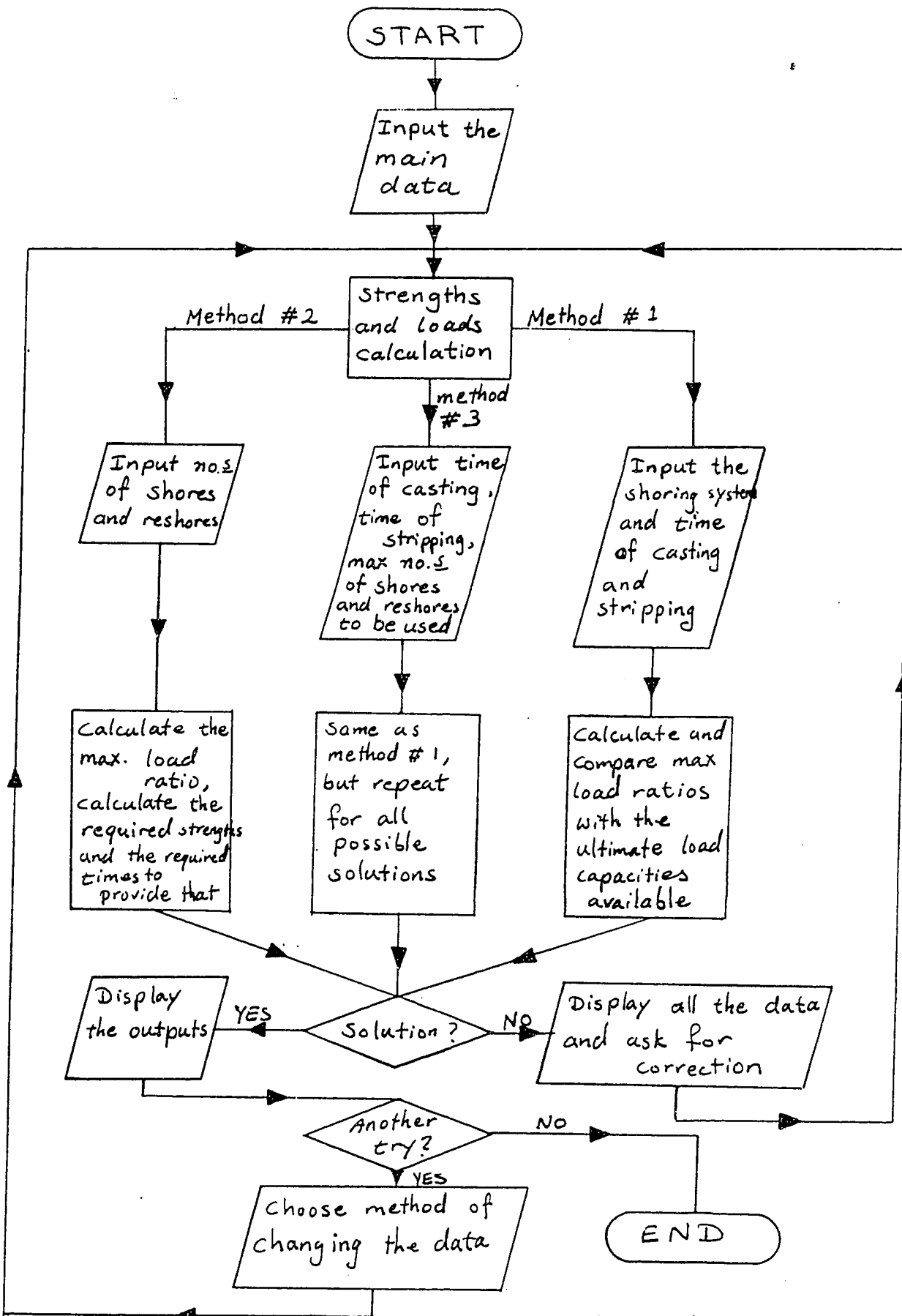


Fig. 3-54 Plots of the compressive strength development equations used in the computer program for CSA type 30 cement concrete.

Fig. 4-1 Flow chart of SHORE program.



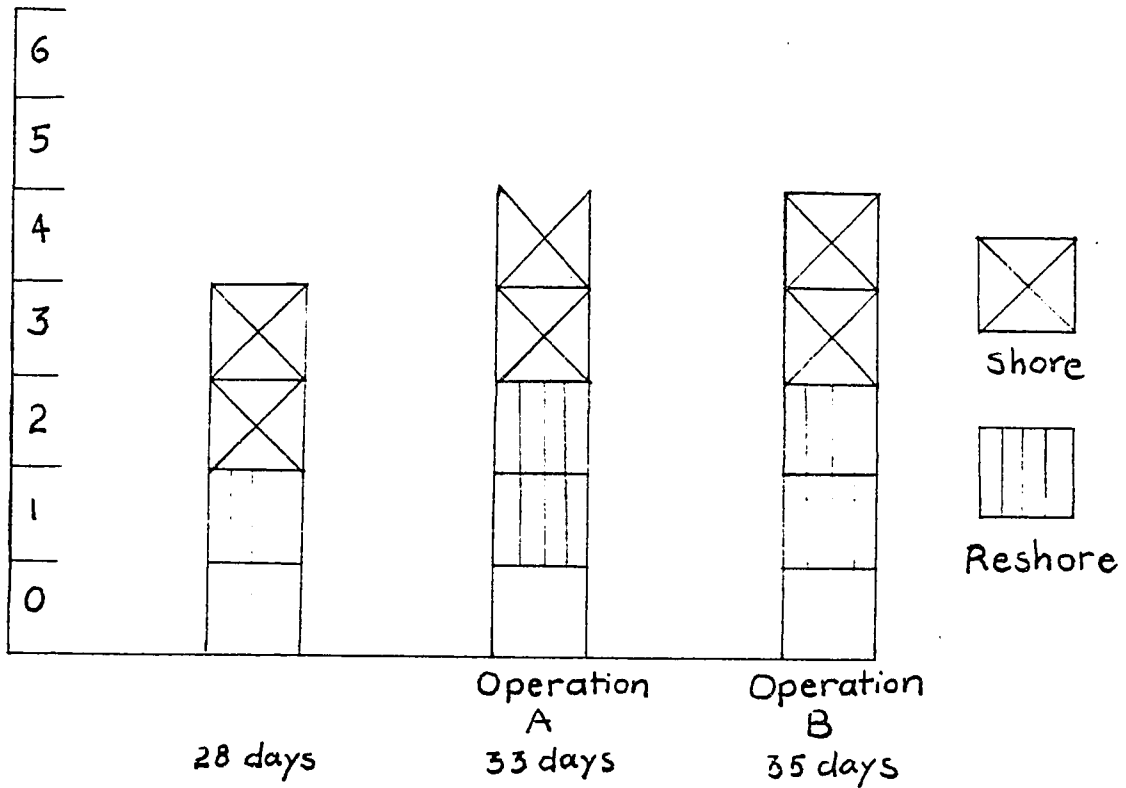


Fig. 4-2 Shore - reshore for a two-shore plus two-reshore construction schedule for casting slab # 5.

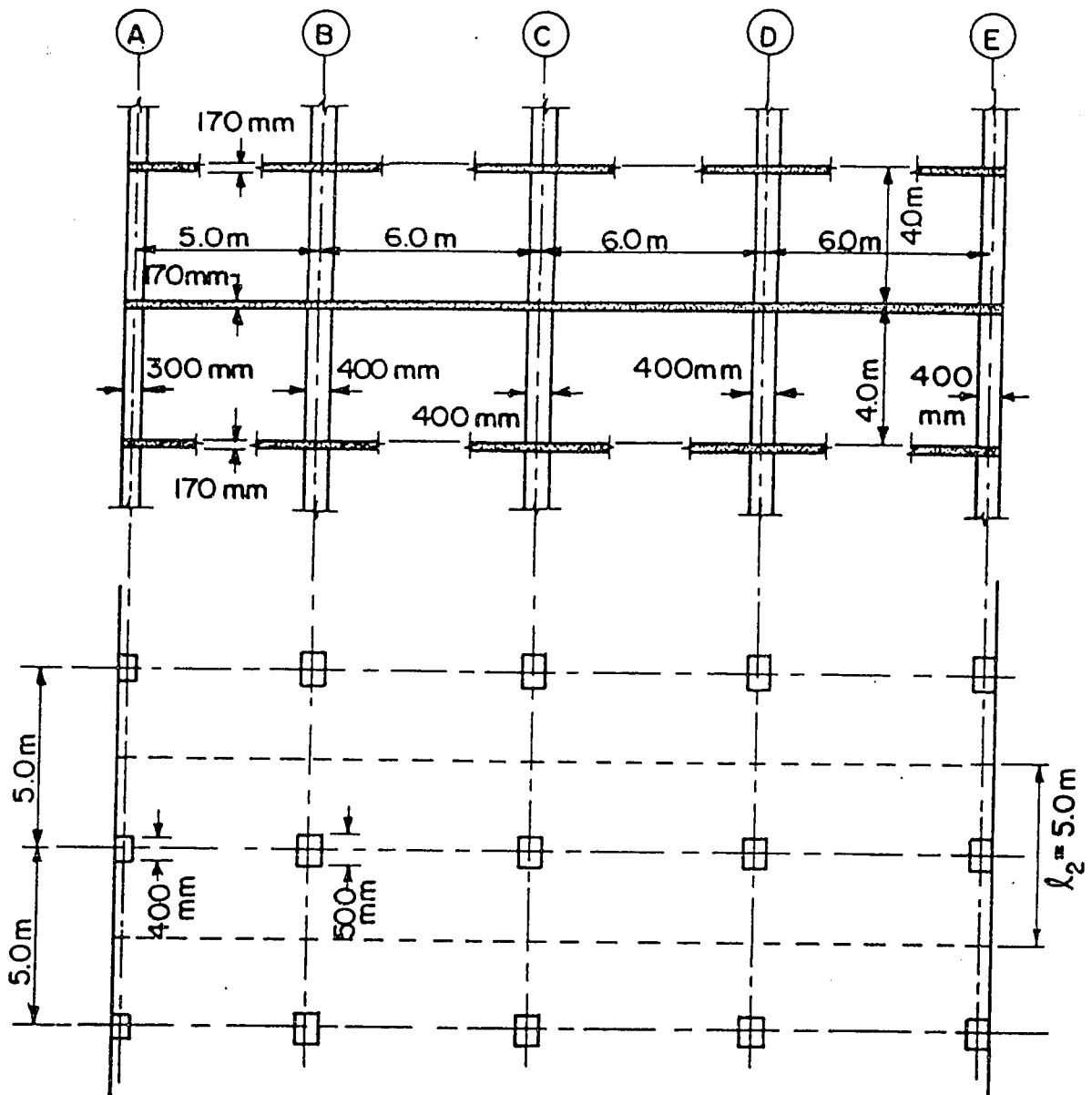


Fig. 5-1 Floor plan for the example problem. (28)

## APPENDIX 1

SHORE - RESHORE CONSTRUCTION SCHEDULING COMPUTER PROGRAM LIST

```

5 COLOR 15,10,9 : CLS
10 DIM L(30,30,2),MAX(10,2),UAVAIL(10,2),S(10,2),Y(30),T(10,2),SLAB(10,2)
15 PRINT
20 PRINT TAB(13)"SHORE - RESHORE CONSTRUCTION SCHEDULING ANALYSIS PROGRAM"
21 PRINT TAB(13)"-----"
25 PRINT :PRINT :PRINT :PRINT TAB(39)"BY"
30 PRINT :PRINT TAB(34)"ALI MUSCATI"
35 PRINT :PRINT TAB(30)"UNIVERSITY OF OTTAWA"
40 PRINT :PRINT :PRINT TAB(2)"REFERENCES : "
45 PRINT:PRINT " 1. A.MUSCATI 'SHORE-RESHORE CONSTRUCTION SCHEDULING ANALYSIS CO
MPUTER PROGRAM', A MASTER OF ENGINEERING THESIS, CIVIL ENG.DEPT., UNIVERSITY
OF OTTAWA, JULY 1986."
50 PRINT :PRINT" 2. N.J.GARDNER 'CONTROL OF CONSTRUCTION LOADS ON MULTIFLOOR BUI
LDINGS', CANADIAN JOURNAL OF CIVIL ENGINEERING, V.6, NO.2, 1979."
99 FOR I=1 TO 25000 : NEXT I
160 CLS :PRINT:PRINT" DATA INPUT : ":PRINT" -----":PRINT
200 PRINT " TYPE OF CEMENT TO BE USED:":PRINT TAB(29)"ENTER 10 FOR TYPE 10 ,OR
210 INPUT " ENTER 30 FOR TYPE 30 : ".TYPE :PRINT
220 INPUT " CURING TEMPERATURE IN DEGREE CELSIUS = ".CIEMP:PRINT
260 PRINT " DESIGN CODE USED : ":INPUT " ENTER CSA OR ACI : ".CODES:PRINT
270 PRINT " LOADS IN KPa : "
280 INPUT " LIVE LOAD = ".LLOAD:INPUT " DEAD LOAD = ".DLOAD
300 PRINT " CONSTRUCTION LIVE LOAD,":INPUT " (SUGGESTED VALUE = 2.4) =
" ,CLOAD :PRINT
305 PRINT " INPUT RATIO OF FORMWORK WEIGHT TO DEAD LOAD:":PRINT " SUGG
ESTED VALUES :":PRINT TAB(23)"FOR WOOD AND ALUMINIUM FORMS = .1" :PRI
NTI TAB(23)"FOR STEEL FORMS = .2":INPUT " RATIO = ".RAI
306 FW=1+RAI:PRINT
310 INPUT " TOTAL NUMBER OF FLOORS = ".NS
320 PRINT:PRINT" THIS PROGRAM IS BASED ON THE FOLLOWING RELATIONSHIP :
321 PRINT " -----":PRINT
325 PRINT TAB(3)"SHEAR STRENGTH = CONSTANT*(COMPRESSIVE STRENGTH)^P":PRINT
330 PRINT " THE SUGGESTED VALUES FOR P ARE :":PRINT
340 PRINT TAB(16)"1. ACCORDING TO ZSUTTY : P = .333
350 PRINT TAB(16)"2. ACCORDING TO ACI & CSA CODES : P = .5
360 PRINT TAB(16)"3. ACCORDING TO GARDNER AND POON : P = .8
370 PRINT TAB(16)"4. MOST CONSERVATIVE : P = 1.0":PRINT
371 INPUT " CHOOSE P VALUE , P = ".POWER :PRINT
375 PRINT" SPECIFIED DESIGN COMPRESSIVE STRENGTH OF CONCRETE." : PRINT" AT 2
8 DAYS WITH A CURING TEMP. OF 22 C .": INPUT " IN MPA
" ,STREN
379 PRINT :PRINT :GOSUB 6600
381 PRINT" THE 28 DAYS-EXPERIMENTAL COMPRESSIVE STRENGTH FOR TYPE"TYPE",AT":PRI
NTI "CIEMP"C CURING TEMPERATURE, ACCORDING TO GARDNER AND SAU EXPERIMENTAL ": P
RINT " RESULTS = "Y(28) "MPA"
382 PRINT:PRINT " FOR CONSTRUCTION PURPOSE, THE MIX STRENGTH SHOULD BE DESIGNED
SO THAT 90 % OF THE TEST RESULTS ARE ABOVE THE SPECIFIED DESIGN COMPRESSIVE
STRENGTH."
384 PRINT :PRINT" ENTER SPECIFIED CONSTRUCTION COMPRESSIVE STRENGTH OF CONCRET
E.":PRINT " AT 28 DAYS FOR "CIEMP" C CURING TEMPERATURE, IN MPa.":INPUT "
OR PRESS <RETURN> TO TAKE THE GIVEN EXPERIMENTAL VALUE = ".CS28

```

```

386 IF CS28=0 THEN 389
388 STRR = SIREN * Y(28)/CS28:GOTO 390
389 CS28=Y(28):STRR=SIREN
390 PRINT:PRINT:PRINT " DO YOU WANT YOUR OUTPUT TO BE PRINTED ON A HARD COPY ?"
395 INPUT "                                     ENTER YES OR NO : ".PRIS:PRINT
396 IF PRIS="YES" THEN 400
397 PRIS="NO"
400 PRINT " CHOOSE METHOD OF ANALYSIS : "
401 PRINT " -----" :PRINT
420 PRINT" METHOD # 1. INPUT TYPE OF SHORING SYSTEM,CASTING TIME,AND STRIPPING
430 PRINT TAB(15)"TIME TO FIND OUT IF THE CYCLE IS SAFE OR NOT.":PRINT
440 PRINT" METHOD # 2. INPUT TYPE OF SHORING SYSTEM TO FIND OUT TIME OF
450 PRINT TAB(15) "CASTING ,AND TIME OF STRIPPING.":PRINT
460 PRINT" METHOD # 3. INPUT TIME OF CASTING AND ,TIME OF STRIPPING TO FIND OUT
470 PRINT TAB(15) "TYPE OF SHORING SYSTEM.":PRINT
480 INPUT " ENTER 1 TO 3 : ".NMETH :PRINT
490 LLR=LLOAD/DLOAD:CLR=CLOAD/DLOAD
500 IF CODES="ACI" THEN 550
520 FD=1.25 :FL=1.5 :GOTO 560
550 FD=1.4:FL=1.7
560 UMAX=FD+FL*LLR :NSOLU=0 :REM NSOLU FOR METHOD # 3 ONLY
580 IF NMETH=1 THEN 585 ELSE GOTO 2000

```

581 REM METHOD # 1

```

585 GOSUB 4200
640 GOSUB 4000
650 GOSUB 4100
900 GOSUB 6000
1210 REM TO CALCULATE U NEEDED GOTO SUBROUTINE 7000 & 8000
1220 IF NFORM=1 THEN GOSUB 8000 ELSE GOSUB 7000
1230 GOSUB 5000
1245 OK=0 : NOTOK=0
1250 FOR I=1 TO NFORM
1260 FOR K=1 TO 2
1300 IF MAX(I,K) <= UAVAIL(I,K) THEN 1500
1310 IF PRIS="NO" THEN 1340
1315 IF NOTOK=100 THEN 1330
1320 LPRINT " THE CHOSEN CYCLE IS NOT SAFE.":LPRINT
1330 LPRINT" (ULTIMATE LOAD CAPACITY REQUIRED FOR SLAB #"SLAB(I,K)"="MAX(I,K)"TI
IMES THE DEAD LOAD)":LPRINT" > (ULTIMATE LOAD CAPACITY AVAILABLE =" U
AVAIL(I,K)"TIMES THE DEAD LOAD)"
1340 IF NOTOK=100 THEN 1360
1350 PRINT " THE CHOSEN CYCLE IS NOT SAFE.":PRINT : NOTOK=100
1360 PRINT" (ULTIMATE LOAD CAPACITY REQUIRED FOR SLAB #"SLAB(I,K)"="MAX(I,K)"TI
MES THE DEAD LOAD)": PRINT" > (ULTIMATE LOAD CAPACITY AVAILABLE =" UA
VAIL(I,K)"TIMES THE DEAD LOAD)"
1390 NSLABC=SLAB(I,K)+NFORM :OK=100
1400 IF K=2 THEN 1425
1420 XS="A" : GOTO 1430
1425 XS="B"
1430 IF PRIS="NO" THEN 1450
1445 LPRINT" THIS HAPPENS AT CYCLE #" I;XS:LPRINT " ON SLAB #" SLAB(I,K)
:LPRINT " SLAB BEING CAST IS #" NSLABC:LPRINT
1450 PRINT " THIS HAPPENS AT CYCLE #" I;XS:PRINT " ON SLAB #" SLAB(I,K)
:PRINT " SLAB BEING CAST IS #" NSLABC:PRINT

```

```

1500 NEXT K
1520 NEXT I
1530 IF OK=100 THEN 1570
1540 IF PRIS="NO" THEN 1560
1550 LPRINT:LPRINT TAB(3) "THE CHOSEN CYCLE IS SAFE.":LPRINT
1560 PRINT:PRINT TAB(3) "THE CHOSEN CYCLE IS SAFE.":PRINT :GOTO 1720
1570 COLOR 14,10,9:PRINT" PRESS F5 (CONT) TO CONTIUE RUNNING THE PROGRAM.":
      COLOR 15,10,9:STOP
1580 PRINT :PRINT " OTHER ALTERNATIVES ARE AVAILABLE :":
1582 PRINT " -----" :PRINT
1590 IF TYPE=30 THEN 1610
1600 PRINT " * USE TYPE 30 CEMENT CONCRETE."
1610 PRINT " * USE A NON-UNIFORM CONSTRUCTION CYCLE."
      :PRINT " * CHANGE THE SHORE-RESHORE SCHEDULE EITHER COMPLETELY OR FOR ONE
OR MORE          CYCLES ONLY."
1620 PRINT " * USE SUPERPLASTICIZERS TO INCREASE STRENGTH."
1630 PRINT " * INCREASE THE STRENGTH CAPACITY OF THE SLAB USING COLUMN CAPITAL
S. DROP          PANELS, ETC."
1635 PRINT " * INCREASE THE 28 DAY SPECIFIED CONCRETE STRENGTH TO GIVE SUFFICI
ENT NEEDED      STRENGTH."
1640 PRINT " -THE LAST TWO ALTERNATIVES ARE ADDRESSED TO THE ENGINEER ONLY-"
1641 PRINT
1645 IF PRIS="NO" THEN 1710
1650 LPRINT :LPRINT " OTHER ALTERNATIVES ARE AVAILABLE :":
1660 LPRINT " -----" :LPRINT
1670 IF TYPE=30 THEN 1680
1675 LPRINT " * USE TYPE 30 CEMENT CONCRETE."
1680 LPRINT " * USE A NON-UNIFORM CONSTRUCTION CYCLE."
      :LPRINT " * CHANGE THE SHORE-RESHORE SCHEDULE EITHER COMPLETELY OR FOR ON
E OR MORE          CYCLES ONLY."
1685 LPRINT " * USE SUPERPLASTICIZERS TO INCREASE STRENGTH."
1690 LPRINT " * INCREASE THE STRENGTH CAPACITY OF THE SLAB USING COLUMN CAPITA
LS. DROP          PANELS, ETC."
1695 LPRINT " * INCREASE THE 28 DAY SPECIFIED CONCRETE STRENGTH TO GIVE SUFFIC
IENT NEEDED      STRENGTH."
1700 LPRINT " -THE LAST TWO ALTERNATIVES ARE ADDRESSED TO THE ENGINEER ONLY-"
"
1701 LPRINT
1710 COLOR 14,10,9:PRINT" PRESS F5 (CONT) TO CONTIUE RUNNING THE PROGRAM.":
      COLOR 15,10,9 :STOP:GOSUB 4300 : GOTO 14400
1720 GOSUB 4300
1740 GOTO 3800

1999 REM METHOD # 2

2000 IF NMETH=3 THEN 3000
2005 GOSUB 4200
2010 GOSUB 4000
2020 IF NFORM=1 THEN GOSUB 8000 ELSE GOSUB 7000
2040 FOR I=1 TO NFORM
2060 FOR K=1 TO 2
2080 S(I,K)=STRR*(MAX(I,K)/UMAX)^(1/POWER)
2100 NEXT K
2120 NEXT I
2140 GOSUB 9000
2200 GOSUB 5000
2210 GOSUB 4300

```

2220 GOTO 3800

3000 REM METHOD # 3

```

3005 GOSUB 4200
3010 GOSUB 4100
3040 INPUT "      MAX NO. OF SHORES TO BE USED  - ",MNFORM
3060 INPUT "      MAX NO. OF RESHORES TO BE USED - ",MNRESH :PRINT
3080 FOR NFORM= 1 TO MNFORM
3100 FOR NRE  - 1 TO (MNRESH+1)
3120 NRESH=NRE-1
3140 GOSUB 6000
3200 IF NFORM=1 THEN GOSUB 8000 ELSE GOSUB 7000
3245 OK=0
3250 FOR I=1 TO NFORM
3260 FOR K=1 TO 2
3300 IF MAX(I,K) <= UAVAIL(I,K) THEN 3500
3400 OK=100
3500 NEXT K
3520 NEXT I
3540 IF OK=100 THEN 3580
3545 NSOLU=NSOLU+1
3550 GOSUB 5000 : GOTO 3600
3580 NEXT NRE
3600 NEXT NFORM
3601 IF NSOLU =0 THEN 3602 ELSE 3610
3602 GOSUB 5000
3603 IF PRIS="NO" THEN 3605
3604 LPRINT"  NO SOLUTION IS POSSIBLE OUT OF THE GIVEN DATA,TRY AGAIN."
      :LPRINT
3605 PRINT"  NO SOLUTION IS POSSIBLE OUT OF THE GIVEN DATA,TRY AGAIN."
      :PRINT
3607 COLOR 14,10,9:PRINT "  PRESS F5 ( CONT ) TO SEE THE DATA AND TRY AGAIN." :C
OLOR 15,10,9:PRINT :PRINT :PRINT :PRINT :STOP:GOSUB 4300:GOTO 14400
3610 GOSUB 4300
3800 PRINT:PRINT "      DO YOU WANT TO CHANGE YOUR DATA AND TRY AGAIN ?
3805 INPUT "                                     ENTER YES OR NO : ",DAT$
3810 IF DAT$="NO" THEN 3990
3815 PRINT:PRINT "      YOU HAVE THE FOLLOWING OPTIONS : "
3820 PRINT TAB(39)"1. CHANGE ALL THE DATA."
      :PRINT TAB(39)"2. CHANGE METHOD OF ANALYSIS."
3830 PRINT TAB(39)"3. SEE THE MAIN DATA AND CHANGE WHAT"
3831 PRINT TAB(43)"IS REQUIRED."
3835 PRINT TAB(39)"4. SEE ALL THE DATA AND CHANGE WHAT"
3836 PRINT TAB(43)"IS REQUIRED." :PRINT
3839 INPUT"                                     ENTER 1 TO 4 : ",DAT
3840 IF DAT=1 THEN 160
3845 IF DAT=4 THEN 14400
3850 IF DAT=2 THEN 400 ELSE GOSUB 4400
3990 END

```

4000 REM INPUT SUB FOR NO. OF SHORES & RESHORES

```

4010 PRINT
4020 INPUT "      NO. OF SHORES  - ",NFORM:INPUT "      NO. OF RESHORES - ",NRESH
4030 PRINT
4050 RETURN

```

4100 REM INPUT SUB FOR TIME OF CASTING & STRIPPING

4110 PRINT :INPUT " TIME OF STRIPPING IN DAYS = ",NSTRIP  
 4120 INPUT " TIME OF CASTING IN DAYS = ",NCAST : PRINT  
 4150 RETURN

4200 REM PRINT METHOD # SUB

4250 PRINT " METHOD #" NMETH "- DATA INPUT :"  
 4260 PRINT " ----- " :PRINT  
 4290 RETURN

4300 REM PRINT \*\*END OF METHOD\*\* SUB

4310 IF PRIS="NO" THEN 4330  
 4320 LPRINT TAB(5) "\*\*\*\*\* END OF METHOD #" NMETH "\*\*\*\*\*":LPRINT:LPRINT  
 4330 PRINT TAB(5) "\*\*\*\*\* END OF METHOD #" NMETH "\*\*\*\*\*":PRINT:PRINT  
 4390 RETURN

4400 REM DATA CHANGING SUBROUTINE

4410 CLS  
 4440 PRINT " INPUT DATA TO BE CHANGED : ":PRINT "-----"  
 4450 PRINT " 1. TYPE OF CEMENT TO BE USED : TYPE" TYPE :PRINT  
 4460 PRINT " 2. CURING TEMPERATURE IN DEGREE CELSIUS = "CTEMP:PRINT  
 4470 PRINT " 3. SPECIFIED DESIGN COMPRESSIVE STRENGTH OF CONCRETE, AT 28 DAYS  
     WITH A CURING TEMPERATURE OF 22 C  
     STREN" MPa":PRINT  
 4480 PRINT " 4. DESIGN CODE USED : "CODE\$:PRINT  
 4485 PRINT " 5. LOADS IN KPa : "  
 4490 PRINT " LIVE LOAD = "LLOAD" DEAD LOAD = "DLOAD" CONSTRUCTION LIVE LOAD  
     = "CLOAD:PRINT  
 4505 PRINT " 6. FORMWORK WEIGHT ="RAI" OF DEAD LOAD." :PRINT  
 4510 PRINT " 7. TOTAL NUMBER OF FLOORS = "NS :PRINT  
 4540 PRINT " 8. SHEAR STRENGTH = CONSTANT\*(COMPRESSIVE STRENGTH)^"POWER:PRINT  
 4545 PRINT " 9. SPECIFIED CONSTRUCTION COMPRESSIVE STRENGTH OF CONCRETE,":PRINT  
     " AT 28 DAYS FOR "CTEMP" C CURING TEMPERATURE = "CS28" MPa":P  
 RINT  
 4550 COLOR 14,10,9:INPUT " ENTER 1 TO 9 OR PRESS < RETURN > IF NO CHANGES ARE  
     REQUIRED = ",CHANGE:COLOR 15,10,9  
 4600 IF CHANGE=1 THEN 4710  
 4620 IF CHANGE=2 THEN 4740  
 4630 IF CHANGE=3 THEN 4760  
 4640 IF CHANGE=4 THEN 4780  
 4650 IF CHANGE=5 THEN 4800  
 4660 IF CHANGE=6 THEN 4860  
 4670 IF CHANGE=7 THEN 4880  
 4680 IF CHANGE=8 THEN 4900  
 4690 IF CHANGE=9 THEN 4965  
 4691 IF CHANGE=0 THEN 4980  
 4710 CLS:PRINT :PRINT " TYPE OF CEMENT TO BE USED:":PRINT TAB(29)"ENTER 10 FOR  
 TYPE 10 ,OR  
 4720 INPUT "  
     ENTER 30 FOR TYPE 30 :",TYPE :GOTO 4410  
 4740 CLS:PRINT :INPUT " CURING TEMPERATURE IN DEGREE CELSIUS = ",CTEMP:GOTO 4410

```

4760 CLS:PRINT :PRINT " SPECIFIED DESIGN COMPRESSIVE STRENGTH OF CONCRETE," :
PRINT " AT 28 DAYS WITH A CURING TEMP. OF 22 C ,": INPUT " IN MPA
      = ",STREN : GOTO 4410
4780 CLS:PRINT :PRINT" DESIGN CODE USED :":INPUT" ENTER CSA OR ACI : ".CODE$
      :GOTO 4410
4800 CLS:PRINT :PRINT " LOADS IN KN/SQ M : "
4820 INPUT " LIVE LOAD = ".LLOAD:INPUT " DEAD LOAD = ".DLOAD
4840 PRINT " CONSTRUCTION LIVE LOAD ,":INPUT " (SUGGESTED VALUE = 2.4) = "
      .CLOAD :GOTO 4410
4860 CLS:PRINT :PRINT " INPUT RATIO OF FORMWORK WEIGHT TO DEAD LOAD:": PRINT"
      SUGGESTED VALUES :":PRINT TAB(23)"FOR WOOD AND ALUMINIUM FORMS = .1" :PRINT T
AB(23)"FOR STEEL FORMS
      = .2":INPUT " RATIO=" ,RAT:FW=1+RAT :GOTO 4
410
4880 CLS:PRINT :INPUT " TOTAL NUMBER OF FLOORS = ".NS:GOTO 4410
4900 CLS:PRINT :PRINT" THIS PROGRAM IS BASED ON THE FOLLOWING RELATIONSHIP :
4920 PRINT " -----":PRINT
4925 PRINT TAB(3)"SHEAR STRENGTH = CONSTANT*(COMPRESSIVE STRENGTH)^P":PRINT
4930 PRINT " THE SUGGESTED VALUES FOR P ARE :":PRINT
4935 PRINT TAB(16)"1. ACCORDING TO ZSUTTY : P = .333
4940 PRINT TAB(16)"2. ACCORDING TO ACI & CSA CODES : P = .5
4945 PRINT TAB(16)"3. ACCORDING TO GARDNER AND POON : P = .8
4950 PRINT TAB(16)"4. MOST CONSERVATIVE : P = 1.0":PRINT
4960 INPUT " CHOOSE P VALUE , P = ".POWER:GOTO 4410
4965 CLS:PRINT :PRINT " SPECIFIED DESIGN COMPRESSIVE STRENGTH OF CONCRETE, AT 2
8 DAYS WITH A CURING TEMPERATURE OF 22 C
      = " STREN" MPa"
4967 PRINT :PRINT :GOSUB 6600
4969 PRINT" THE 28 DAYS-EXPERIMENTAL COMPRESSIVE STRENGTH FOR TYPE"TYPE",AT":PR
INT" "CTEMP"C CURING TEMPERATURE, ACCORDING TO GARDNER AND SAU EXPERIMENTAL " :
PRINT " RESULTS = "Y(28) "MPa"
4971 PRINT:PRINT " FOR CONSTRUCTION PURPOSE, THE MIX STRENGTH SHOULD BE DESIGNE
D SO THAT 90 % OF THE TEST RESULTS ARE ABOVE THE SPECIFIED DESIGN COMPRESSIVE
STRENGTH."
4972 PRINT :PRINT" ENTER SPECIFIED CONSTRUCTION COMPRESSIVE STRENGTH OF CONCRE
TE ,":PRINT " AT 28 DAYS FOR "CTEMP" C CURING TEMPERATURE, IN MPa.":INPUT "
OR PRESS <RETURN> TO TAKE THE GIVEN EXPERIMENTAL VALUE = ",CS28
4973 IF CS28=0 THEN 4975
4974 STRR = STREN * Y(28)/CS28:GOTO 4410
4975 CS28=Y(28):STRR=STREN :GOTO 4410
4980 GOSUB 6600
4982 STRR = STREN * Y(28)/CS28:GOTO 390
4999 RETURN

```

5000 REM PRINT SUBROUTINE

```

5000 REM PRINT SUBROUTINE
5005 IF NSOLU > 1 THEN 5500
5007 IF DAT=2 THEN 5141
5010 IF PRIS="NO" THEN 5220
5020 LPRINT TAB(13)"SHORE - RESHORE CONSTRUCTION SCHEDULING ANALYSIS PROGRAM"
5030 LPRINT TAB(13)"-----"
5040 LPRINT:LPRINT" INPUT DATA : ":LPRINT" -----":LPRINT
5050 LPRINT :LPRINT " TYPE OF CEMENT TO BE USED: TYPE" TYPE :LPRINT
5060 LPRINT" CURING TEMPERATURE IN DEGREE CELSIUS = "CTEMP:LPRINT
5070 LPRINT" SPECIFIED DESIGN COMPRESSIVE STRENGTH OF CONCRETE," :LPRINT" AT
28 DAYS WITH A CURING TEMPERATURE OF 22 C = "STREN "MPa":LPRINT
5075 LPRINT " SPECIFIED CONSTRUCTION COMPRESSIVE STRENGTH OF CONCRETE,":LPRINT
" AT 28 DAYS FOR "CTEMP" C CURING TEMPERATURE = "CS28"MPa":LPRINT

```

```

5080 LPRINT " DESIGN CODE USED : "CODE$:LPRINT
5085 LPRINT " LOADS IN KPa : "
5090 LPRINT " LIVE LOAD - " LLOAD:LPRINT
      " DEAD LOAD - " DLOAD
5100 LPRINT " CONSTRUCTION LIVE LOAD - " CLOAD :LPRINT
5105 LPRINT " FORMWORK WEIGHT -"RAT" OF DEAD LOAD." :LPRINT
5110 LPRINT " TOTAL NUMBER OF FLOORS - "NS :LPRINT
5120 LPRINT" THIS ANALYSIS IS BASED ON THE FOLLOWING RELATIONSHIP : "
5130 LPRINT" -----":LPRINT
5140 LPRINT" SHEAR STRENGTH - CONSTANT*(COMPRESSIVE STRENGTH)^"POWER":LPRINT:
      LPRINT
5141 IF PRIS="NO" THEN 5220
5142 LPRINT " METHOD # " NMETH": "
5143 LPRINT " -----" :PRINT
5145 IF NMETH =3 THEN 5160
5150 LPRINT" "NFORM" LEVEL(S) OF SHORES ":LPRINT" " NRESH" LEVEL(S) OF RESHORES"
5160 LPRINT :LPRINT " TIME OF STRIPPING -"NSTRIP " DAYS"
5170 LPRINT " TIME OF CASTING -"NCAST " DAYS" :LPRINT
5220 IF NMETH =3 THEN 5260
5225 IF NMETH=1 THEN 5600
5230 PRINT :PRINT " TIME OF STRIPPING -"NSTRIP " DAYS"
5240 PRINT " TIME OF CASTING -"NCAST " DAYS" : PRINT
5250 IF NMETH <>3 THEN 5600
5260 IF PRIS="NO" THEN 5500
5265 REM LPRINT COM FOR METHOD # 3
5270 LPRINT " MAX NO. OF SHORES TO BE USED -"MNFORM
5290 LPRINT " MAX NO. OF RESHORES TO BE USED -"MNRESH :LPRINT
5500 REM PRINT SUBROUTINE FOR METHOD # 3 ONLY
5505 IF NSOLU=0 THEN 5600
5510 IF PRIS="NO" THEN 5550
5520 LPRINT :LPRINT " SOLUTION # " NSOLU " : "
5521 LPRINT " -----"
5530 LPRINT" "NFORM" LEVEL(S) OF SHORES WITH A MINIMUM OF":LPRINT" " NRESH"
LEVEL(S) OF RESHORES"
5531 LPRINT
5550 PRINT : PRINT " SOLUTION # " NSOLU " : "
5551 PRINT " -----"
5590 PRINT " "NFORM " LEVEL(S) OF SHORES WITH A MINIMUM OF":PRINT" " NRESH"
LEVEL(S) OF RESHORES"
5591 PRINT
5600 RETURN

```

6000 REM STRENGTH SUBROUTINE

```

6020 I(1,1)=NSTRIP : I(1,2)=NCAST
6040 FOR I=2 TO NFORM
6050 FOR K=1 TO 2
6060 I(I,K)=I(I-1,K)+NCAST
6080 NEXT K
6090 NEXT I
6300 FOR I=1 TO NFORM
6315 FOR K=1 TO 2
6360 IF CTEMP < IMAX THEN 6400
6380 S(I,K)=SUMAX*KIMAX*(T(I,K)-TOMAX)/(1+KIMAX*(T(I,K)-TOMAX)):GOTO 6480
6400 IF CTEMP > IMIN THEN 6450
6420 S(I,K)=SUMIN*KIMIN*(T(I,K)-TOMIN)/(1+KIMIN*(T(I,K)-TOMIN)):GOTO 6480
6450 S(I,K)=SU*KI*(T(I,K)-TO)/(1+KI*(T(I,K)-TO))
6480 UAAVAIL(I,K)=CINT(100*UMAX*(S(I,K)/STRR)^POWER)/100

```

```

6500 NEXT K
6520 NEXT I
6540 RETURN

```

6600 REM INTERPOLATION AND APPLYING EQU. 3-4 AND FINDING THE 28 DAYS STRENGTH SUBROUTINE

```

6610 IF TYPE=30 THEN 6618
6612 SUMAX=33:SUMIN=25:KIMAX=.182:KIMIN=.106:TOMAX=.694:TOMIN=.61
6614 IMAX=16:IMIN=0:N=30
6616 GOTO 6622
6618 SUMAX=53:SUMIN=42:KIMAX=.357:KIMIN=.305:TOMAX=.182:TOMIN=.72
6620 IMAX=22:IMIN=0:N=30
6622 IF CTEMP<= IMIN THEN 6760
6624 IF CTEMP>= IMAX THEN 6760
6636 SX=0:SY=0:SSX=0:SSY=0:SXY=0
6637 SU=(SUMAX-SUMIN)*CTEMP/(IMAX-IMIN)+SUMIN
6638 FOR K=0 TO N
6639 I=K/2
6640 SMAX=SUMAX*KIMAX*(I-TOMAX)/(1+KIMAX*(I-TOMAX))
6641 SMIN=SUMIN*KIMIN*(I-TOMIN)/(1+KIMIN*(I-TOMIN))
6650 Y(I)=(SMAX-SMIN)*CTEMP/(IMAX-IMIN)+SMIN
6655 Y(I)=Y(I)/(SU-Y(I))
6660 SX=SX+I
6670 SY=SY+Y(I)
6680 SSX=SSX+I2
6690 SSY=SSY+Y(I)*Y(I)
6700 SXY=SXY+I*Y(I)
6710 NEXT
6720 XAU=SX/N:YAU=SY/N
6740 KI=(SXY-N*XAU*YAU)/(SSX-N*XAU*XAU)
6750 A=YAU-KI*XAU
6756 IO=-A/KI
6760 IF CTEMP < IMAX THEN 6780
6770 Y(28)=SUMAX*KIMAX*(28-TOMAX)/(1+KIMAX*(28-TOMAX)):GOTO 6820
6780 IF CTEMP > IMIN THEN 6800
6790 Y(28)=SUMIN*KIMIN*(28-TOMIN)/(1+KIMIN*(28-TOMIN)):GOTO 6820
6800 Y(28)=SU*KI*(28-IO)/(1+KI*(28-IO))
6820 Y(28)=CINI(100*Y(28))/100
6900 RETURN

```

7000 REM MAX LOAD RATIO SUBROUTINE

```

7009 FOR I=1 TO NS
7010 FOR J=1 TO NS
7011 FOR K=1 TO 2
7012 L(I,J,K)=1
7013 NEXT K
7014 NEXT J
7015 NEXT I
7040 NSIAR = NFORM+1
7050 NFIN = NS
7055 K=NSIAR : REM K=NO. OF CYCLE
7060 FOR J=1 TO NSIAR-1
7070 L(K,J,1)=1 :L(K,J,2)=1
7080 NEXT
7090 L(K,K,1)=0 :L(K,K,2)=0

```

```

7106 IF NRESH > 0 THEN 7115
7108 FOR J=1 TO NSTAR-1
7109 L(K,J,2)=L(K,J,1)+1/NFORM :NEXT
7115 FOR K=NSTAR+1 TO NFIN
7120 ND=K-1-NFORM
7130 DF=0
7140 FOR J=1 TO ND
7150 L(K,J,1)=1:L(K,J,2)=1
7160 DF=DF+L(K-1,J,2)-L(K,J,1)
7170 NEXT J
7175 NA=NFORM+NRESH+2
7180 FOR J=ND+1 TO K-1
7185 IF K>= NA THEN 7195
7190 L(K,J,1)=L(K-1,J,2)+1/NFORM+DF/NFORM :GOTO 7198
7195 L(K,J,1)=L(K-1,J,2)+DF/NFORM
7198 L(K,J,2)=L(K,J,1)
7200 NEXT
7210 L(K,K,1)=0 :L(K,K,2)=0
7255 NBB=K-NFORM-NRESH
7260 IF NBB <= 0 THEN 7400
7280 NB=K-1-NRESH-NFORM
7290 FOR J=NB+1 TO K-1
7300 L(K,J,2)=L(K,J,1)+1/(NFORM+NRESH)
7310 NEXT J
7320 FOR J=1 TO NB
7330 L(K,J,2)=1
7340 NEXT
7400 NEXT K
7510 FOR K=1 TO 2
7520 FOR I=1 TO NFIN
7530 FOR J=1 TO NFIN
7540 L(I,J,K)=L(I,J,K)*1.1*FD
7550 IF I< (NFORM+NRESH+1) THEN 7580
7560 L(I,J,K)=L(I,J,K)*FW+FL*CLR/(NRESH+NFORM)
7580 NEXT J
7590 NEXT I
7595 NEXT K
7600 FOR I=1 TO NFORM
7605 MAX(I,1)=0:MAX(I,2)=0
7610 SLAB(I,1)=0:SLAB(I,2)=0
7620 FOR J=1 TO (NFIN-1)
7625 IF L(J+I,J,1) <= MAX(I,1) THEN 7640
7630 MAX(I,1)=CINT(L(J+I,J,1)*100)/100:SLAB(I,1)=J
7640 IF L(J+I,J,2) <= MAX(I,2) THEN 7650
7645 MAX(I,2)=CINT(L(J+I,J,2)*100)/100:SLAB(I,2)=J
7650 NEXT J
7700 NEXT I
7710 RETURN

```

8000 REM SUBROUTINE FOR MAX LOAD RATIO FOR NO. OF SHORES = 1

```

8009 FOR I=1 TO NS
8010 FOR J=1 TO NS
8011 FOR K=1 TO 2
8012 L(I,J,K)=1
8013 NEXT K
8014 NEXT J
8015 NEXT I
8503 SLAB(1,1)=NRESH+NFORM:SLAB(1,2)=SLAB(1,1)

```

```

8505 IF NRESH=0 THEN B610
8510 MAX(1,1)=1 :MAX(1,2)=1+1/(NFORM+NRESH)
8520 FOR K=1 TO 2
8540 MAX(1,K)=CINT(MAX(1,K)*1.1*FD*100)/100
8560 MAX(1,K)=CINT(100*(MAX(1,K)*FW+FL*CLR/(NRESH+NFORM)))/100
8600 NEXT
8605 GOTO 8700
8610 MAX(1,1)=CINT(FW*FD*100)/100
8620 MAX(1,2)=CINT(((1+1*FW)*FD+FL*CLR)*100)/100
8700 RETURN

9000 REM TIME SUBROUTINE
9300 FOR I=1 TO NFORM
9315 FOR K=1 TO 2
9360 IF CTEMP < TMAX THEN 9400
9370 IF S(I,K) < SUMAX THEN 9380
9375 SM = SUMAX : GOSUB 9800
9380 T(I,K)=S(I,K)/((SUMAX-S(I,K))*KTMAX)+TOMAX :GOTO 9500
9400 IF CTEMP > TMIN THEN 9450
9410 IF CTEMP < TMIN THEN 314
9450 IF S(I,K) < SU THEN 9460
9455 SM = SU : GOSUB 9800
9460 T(I,K)=S(I,K)/((SU-S(I,K))*KT)+T0
9500 NEXT K
9520 NEXT I
9540 NSTRIP=T(1,1) :NCAST=T(1,2)
9560 FOR I=2 TO NFORM
9561 IF (T(I,2)-T(I-1,2)) <= NCAST THEN 9580
9562 NCA=T(I,2)/I
9563 IF NCA <= NCAST THEN 9580
9564 NCAST = NCA
9580 IF (T(I,1)-T(I-1,2)) <= NSTRIP THEN 9660
9600 NST=T(I,1)-NCAST*(I-1)
9610 IF NST<=NSTRIP THEN 9660
9615 NSTRIP=NST
9660 NEXT I
9665 NSTRIP = CINT(10*NSTRIP)/10 : NCAST=CINT(10*NCAST)/10
9700 RETURN
9800 REM IF SU > STRENGTH SUBROUTINE
9805 SREQ= CINT(100*S(I,K))/100 : SM= CINT(SM*CS28/Y(28)*100)/100
9810 PRINT :PRINT " NO SOLUTION IS POSSIBLE OUT OF THE GIVEN DATA, THE REQUIRED
STRENGTH ("SREQ" MPa ) > THE ULTIMATE STRENGTH ("SM" MPa ) AT
NE YEAR."
9820 PRINT :PRINT " THERE MAY BE A MISTAKE IN THE MAIN INPUT DATA OR IT IS NOT
POSSIBLE TO USE THIS SHORING SYSTEM ":PRINT:PRINT
9821 IF PRT$="NO" GOTO 9830
9822 CONTL=9800
9823 GOTO 5000
9824 LPRINT :LPRINT" NO SOLUTION IS POSSIBLE OUT OF THE GIVEN DATA, THE REQUIRE
D STRENGTH ("SREQ" MPa ) > THE ULTIMATE STRENGTH ("SM" MPa ) AT
ONE YEAR."
9830 COLOR 14,10,9:PRINT " PRESS F5 ( CONT ) TO SEE THE DATA AND TRY AGAIN." :C
OLOR 15,10,9:PRINT :PRINT :PRINT :PRINT :SOL$="NO ":STOP:GOTO 14400

14400 REM DATA CHANGING SUBROUTINE

14410 CLS
14440 PRINT" INPUT DATA :":PRINT" -----"

```

```

14450 PRINT " 1. TYPE OF CEMENT TO BE USED : TYPE" TYPE
14460 PRINT " 2. CURING TEMPERATURE IN DEGREE CELSIUS = "CTEMP
14470 PRINT " 3. SPECIFIED DESIGN COMPRESSIVE STRENGTH OF CONCRETE, AT 28 DAYS
      WITH A CURING TEMPERATURE OF 22 C
      STREN" MPa"
14480 PRINT " 4. DESIGN CODE USED : "CODE$
14485 PRINT " 5. LOADS IN KPa : "
14490 PRINT "      LIVE LOAD = "LLOAD" DEAD LOAD = "DLOAD" CONSTRUCTION LIVE LOA
D = "CLOAD
14505 PRINT " 6. FORMWORK WEIGHT = "RAI" OF DEAD LOAD."
14510 PRINT " 7. TOTAL NUMBER OF FLOORS = "NS
14540 PRINT " 8. SHEAR STRENGTH = CONSTANT*(COMPRESSIVE STRENGTH)"POWER
14545 PRINT " 9. SPECIFIED CONSTRUCTION COMPRESSIVE STRENGTH OF CONCRETE,":PRINT
      "      AT 28 DAYS FOR "CTEMP" C CURING TEMPERATURE
      = "CS28" MPa":
PRINT:COLOR 14,10,9
14548 PRINT " 10. METHOD OF ANALYSIS # - "NMETH
14550 IF NMETH = 2 THEN 14570
14555 PRINT " 11. TIME OF STRIPPING = "NSTRIIP " DAYS, TIME OF CASTING = " NCA
ST" DAYS": IF NMETH = 3 THEN 14580
14560 PRINT " 12. "NFORM" LEVEL(S) OF SHORES, " NRESH" LEVEL(S) OF RESHORES"
14565 IF NMETH <> 2 THEN 14578
14570 PRINT " 11. "NFORM" LEVEL(S) OF SHORES, " NRESH" LEVEL(S) OF RESHORES"
14575 GOTO 14590
14578 IF NMETH = 1 THEN 14590
14580 PRINT " 12. MAX NO. OF SHORES TO BE USED = "MNFORM
14585 PRINT "      MAX NO. OF RESHORES TO BE USED = "MNRESH
14590 COLOR 15,10,9:PRINT :PRINT " 13. PRINT OUT ON A HARD COPY : "PRIS
14593 PRINT " 14. TO ESCAPE.":PRINT
14595 INPUT"      ENTER 1 TO 14 OR PRESS < RETURN > TO CONTINUE = " ,CHAN
14600 COLOR 15,10,9:IF CHAN =-1 THEN 14710
14620 IF CHAN =-2 THEN 14740
14630 IF CHAN =-3 THEN 14760
14640 IF CHAN =-4 THEN 14780
14650 IF CHAN =-5 THEN 14800
14660 IF CHAN =-6 THEN 14860
14670 IF CHAN =-7 THEN 14880
14680 IF CHAN =-8 THEN 14900
14690 IF CHAN =-9 THEN 14965
14691 IF CHAN =-0 THEN 14980
14695 IF CHAN =-10 THEN 15000
14700 IF CHAN =-11 THEN 15100
14705 IF CHAN =-12 THEN 15200
14707 IF CHAN =-13 THEN 15300
14708 IF CHAN =-14 THEN 3800
14710 CLS:PRINT :PRINT " TYPE OF CEMENT TO BE USED:":PRINT TAB(29)"ENTER 10 FOR
TYPE 10 ,OR
14720 INPUT "      ENTER 30 FOR TYPE 30 :",TYPE:GOTO 14410
14740 CLS:PRINT:INPUT" CURING TEMPERATURE IN DEGREE CELSIUS = ",CTEMP:GOTO 1441
0
14760 CLS:PRINT :PRINT " SPECIFIED DESIGN COMPRESSIVE STRENGTH OF CONCRETE, " :
PRINT"      AT 28 DAYS WITH A CURING TEMP. OF 22 C ,": INPUT "      IN MPA
      = ",STREN : GOTO 14410
14780 CLS:PRINT :PRINT" DESIGN CODE USED :":INPUT" ENTER CSA OR ACI : ",CODE$
14795 GOTO 14410
14800 CLS:PRINT :PRINT " LOADS IN KPa : "
14820 INPUT "      LIVE LOAD = ",LLOAD:INPUT "      DEAD LOAD = ",DLOAD
14840 PRINT "      CONSTRUCTION LIVE LOAD ,":INPUT "      (SUGGESTED VALUE = 2.4) = "
,CLOAD :GOTO 14410

```

```

14860 CLS:PRINT :PRINT " INPUT RATIO OF FORMWORK WEIGHT TO DEAD LOAD:": PRINT"
      SUGGESTED VALUES :":PRINT TAB(23)"FOR WOOD AND ALUMINIUM FORMS = .1":PRINT
TAB(23)"FOR STEEL FORMS          = .2":INPUT"      RATIO=" ,RAT:FW-1+RAT :GOTO
14410
14880 CLS:PRINT :INPUT " TOTAL NUMBER OF FLOORS = ",NS:GOTO 14410
14900 CLS:PRINT :PRINT" THIS PROGRAM IS BASED ON THE FOLLOWING RELATIONSHIP :
14920 PRINT " -----":PRINT
14925 PRINT TAB(3)"SHEAR STRENGTH = CONSTANT*(COMPRESSIVE STRENGTH)^P":PRINT
14930 PRINT " THE SUGGESTED VALUES FOR P ARE :":PRINT
14935 PRINT TAB(16)"1. ACCORDING TO ZSUTTY          : P = .333
14940 PRINT TAB(16)"2. ACCORDING TO ACI & CSA CODES : P = .5
14945 PRINT TAB(16)"3. ACCORDING TO GARDNER AND POON : P = .8
14950 PRINT TAB(16)"4. MOST CONSERVATIVE          : P = 1.0":PRINT
14960 INPUT " CHOOSE P VALUE , P = ".POWER:GOTO 14410
14965 CLS:PRINT :PRINT " SPECIFIED DESIGN COMPRESSIVE STRENGTH OF CONCRETE, AT
28 DAYS          WITH A CURING TEMPERATURE OF 22 C
      = " STREN" MPa"
14967 PRINT :PRINT :GOSUB 6600
14969 PRINT" THE 28 DAYS-EXPERIMENTAL COMPRESSIVE STRENGTH FOR TYPE"TYPE", AT":P
RINT" "CTEMP"C CURING TEMPERATURE, ACCORDING TO GARDNER AND SAU EXPERIMENTAL ":
PRINT " RESULTS = "Y(28) "MPa"
14971 PRINT:PRINT " FOR CONSTRUCTION PURPOSE, THE MIX STRENGTH SHOULD BE DESIGN
ED SO THAT 90 % OF THE TEST RESULTS ARE ABOVE THE SPECIFIED DESIGN COMPRESSIV
E STRENGTH."
14972 PRINT :PRINT" ENTER SPECIFIED CONSTRUCTION COMPRESSIVE STRENGTH OF CONCR
ETE,":PRINT " AT 28 DAYS FOR "CTEMP" C CURING TEMPERATURE, IN MPa.":INPUT "
OR PRESS <RETURN> TO TAKE THE GIVEN EXPERIMENTAL VALUE      = ",CS28
14973 IF CS28=0 THEN 14975
14974 SIRR = STREN * Y(28)/CS28:GOTO 14410
14975 CS28=Y(28):SIRR=STREN :GOTO 14410
14980 GOSUB 6600
14981 SIRR = STREN * Y(28)/CS28:PRINT
14984 LLR=LLOAD/DLOAD:CLR=CLOAD/DLOAD
14985 IF CODES="ACI" THEN 14987
14986 FD=1.25 :FL=1.5 :GOTO 14988
14987 FD=1.4:FL=1.7
14988 UMAX=FD+FL*LLR :NSOLU=0 :REM NSOLU FOR METHOD # 3 ONLY
14989 IF NMETH = 1 THEN 900
14990 IF NMETH = 2 THEN 2020
14995 IF NMETH = 3 THEN 3080
15000 CLS:PRINT :PRINT " CHOOSE METHOD OF ANALYSIS : "
15001 PRINT " -----":PRINT
15002 PRINT" METHOD # 1. INPUT TYPE OF SHORING SYSTEM,CASTING TIME,AND STRIPPIN
G
15030 PRINT TAB(15)"TIME TO FIND OUT IF THE CYCLE IS SAFE OR NOI.":PRINT
15040 PRINT" METHOD # 2. INPUT TYPE OF SHORING SYSTEM TO FIND OUT TIME OF
15050 PRINT TAB(15) "CASTING ,AND TIME OF STRIPPING.":PRINT
15060 PRINT" METHOD # 3. INPUT TIME OF CASTING AND ,TIME OF STRIPPING TO FIND O
UT
15070 PRINT TAB(15) "TYPE OF SHORING SYSTEM.":PRINT
15080 INPUT " ENTER 1 TO 3 : ",NMETH :PRINT:GOTO 14410
15100 CLS:PRINT :IF NMETH = 2 THEN 15120 ELSE 15140
15120 CLS :GOSUB 4000 :GOTO 14410
15140 GOSUB 4100 : GOTO 14410
15200 CLS:PRINT :IF NMETH = 3 THEN 15250
15220 GOSUB 4000 : GOTO 14410
15250 INPUT " MAX NO. OF SHORES TO BE USED      = ",MNFORM

```

```
15260 INPUT "      MAX NO. OF RESHORES TO BE USED = ",MNRESH :PRINT:GOTO 14410
15300 CLS:PRINT:PRINT:PRINT " DO YOU WANT YOUR OUTPUT TO BE PRINTED ON A HARD C
OPY ?"
15310 INPUT "
NT                                     ENTER YES OR NO : ",PRIS:PRI
15320 IF PRIS="YES" THEN 15400
15340 PRIS="NO"
15400 GOTO 14410
```

## APPENDIX 2

## EXAMPLES OF USING SHORE PROGRAM

## EXAMPLE # 1

## SHORE - RESHORE CONSTRUCTION SCHEDULING ANALYSIS PROGRAM

-----  
INPUT DATA :

TYPE OF CEMENT TO BE USED: TYPE 10

CURING TEMPERATURE IN DEGREE CELSIUS - 0

SPECIFIED DESIGN COMPRESSIVE STRENGTH OF CONCRETE,  
AT 28 DAYS WITH A CURING TEMPERATURE OF 22 C - 25 MPaSPECIFIED CONSTRUCTION COMPRESSIVE STRENGTH OF CONCRETE,  
AT 28 DAYS FOR 0 C CURING TEMPERATURE - 18.6 MPa

DESIGN CODE USED : ACI

## LOADS IN KPa :

LIVE LOAD - 6  
DEAD LOAD - 4  
CONSTRUCTION LIVE LOAD - 2

FORMWORKS WEIGHT - .1 OF DEAD LOAD.

TOTAL NUMBER OF FLOORS - 8

THIS ANALYSIS IS BASED ON THE FOLLOWING RELATIONSHIP :  
-----SHEAR STRENGTH = CONSTANT\*(COMPRESSIVE STRENGTH)<sup>.8</sup>METHOD # 2 :  
-----2 LEVEL(S) OF SHORES  
2 LEVEL(S) OF RESHORESTIME OF STRIPPING - 8.54 DAYS  
TIME OF CASTING - 15.46 DAYS

\*\*\*\*\* END OF METHOD # 2 \*\*\*\*\*

## METHOD # 1 :

-----  
 2 LEVEL(S) OF SHORES  
 2 LEVEL(S) OF RESHORES

TIME OF STRIPPING - 5 DAYS  
 TIME OF CASTING - 7 DAYS

THE CHOSEN CYCLE IS NOT SAFE.

(ULTIMATE LOAD CAPACITY REQUIRED FOR SLAB # 4 - 2.75 TIMES THE DEAD LOAD)  
 > (ULTIMATE LOAD CAPACITY AVAILABLE - 2.44 TIMES THE DEAD LOAD)  
 THIS HAPPENS AT CYCLE # 2 A  
 ON SLAB # 4  
 SLAB BEING CAST IS # 6

(ULTIMATE LOAD CAPACITY REQUIRED FOR SLAB # 4 - 3.18 TIMES THE DEAD LOAD)  
 > (ULTIMATE LOAD CAPACITY AVAILABLE - 2.58 TIMES THE DEAD LOAD)  
 THIS HAPPENS AT CYCLE # 2 B  
 ON SLAB # 4  
 SLAB BEING CAST IS # 6

OTHER ALTERNATIVES ARE AVAILABLE :

- 
- \* USE TYPE 30 CEMENT CONCRETE.
  - \* USE A NON-UNIFORM CONSTRUCTION CYCLE.
  - \* CHANGE THE SHORE-RESHORE SCHEDULE EITHER COMPLETELY OR FOR ONE OR MORE CYCLES ONLY.
  - \* USE SUPERPLASTICIZERS TO INCREASE STRENGTH.
  - \* INCREASE THE STRENGTH CAPACITY OF THE SLAB USING COLUMN CAPITALS, DROP PANELS, ETC.
  - \* INCREASE THE 28 DAY SPECIFIED CONCRETE STRENGTH TO GIVE SUFFICIENT NEEDED STRENGTH.
- THE LAST TWO ALTERNATIVES ARE ADDRESSED TO THE ENGINEER ONLY-

\*\*\*\*\* END OF METHOD # 1 \*\*\*\*\*

## METHOD # 1 :

-----  
 2 LEVEL(S) OF SHORES  
 2 LEVEL(S) OF RESHORES

TIME OF STRIPPING - 11 DAYS  
 TIME OF CASTING - 24 DAYS

THE CHOSEN CYCLE IS SAFE.

\*\*\*\*\* END OF METHOD # 1 \*\*\*\*\*

## METHOD # 3 :

-----  
TIME OF STRIPPING - 8 DAYS  
TIME OF CASTING - 15 DAYS

MAX NO. OF SHORES TO BE USED - 2  
MAX NO. OF RESHORES TO BE USED - 2

## SOLUTION # 1 :

-----  
1 LEVEL(S) OF SHORES WITH A MINIMUM OF  
2 LEVEL(S) OF RESHORES

\*\*\*\*\* END OF METHOD # 3 \*\*\*\*\*

## METHOD # 3 :

-----  
TIME OF STRIPPING - 8.600001 DAYS  
TIME OF CASTING - 15.5 DAYS

MAX NO. OF SHORES TO BE USED - 3  
MAX NO. OF RESHORES TO BE USED - 5

## SOLUTION # 1 :

-----  
1 LEVEL(S) OF SHORES WITH A MINIMUM OF  
2 LEVEL(S) OF RESHORES

## SOLUTION # 2 :

-----  
2 LEVEL(S) OF SHORES WITH A MINIMUM OF  
2 LEVEL(S) OF RESHORES

## SOLUTION # 3 :

-----  
3 LEVEL(S) OF SHORES WITH A MINIMUM OF  
3 LEVEL(S) OF RESHORES

\*\*\*\*\* END OF METHOD # 3 \*\*\*\*\*

## EXAMPLE # 2

SHORE - RESHORE CONSTRUCTION SCHEDULING ANALYSIS PROGRAM  
-----INPUT DATA :  
-----

TYPE OF CEMENT TO BE USED: TYPE 30

CURING TEMPERATURE IN DEGREE CELSIUS - 5

SPECIFIED DESIGN COMPRESSIVE STRENGTH OF CONCRETE,  
AT 28 DAYS WITH A CURING TEMPERATURE OF 22 C - 30 MPaSPECIFIED CONSTRUCTION COMPRESSIVE STRENGTH OF CONCRETE,  
AT 28 DAYS FOR 5 C CURING TEMPERATURE - 37.49 MPa

DESIGN CODE USED : CSA

LOADS IN KPa :

LIVE LOAD - 8  
DEAD LOAD - 5  
CONSTRUCTION LIVE LOAD - 2.4

FORMWORKS WEIGHT - .2 OF DEAD LOAD.

TOTAL NUMBER OF FLOORS - 10

THIS ANALYSIS IS BASED ON THE FOLLOWING RELATIONSHIP :  
-----SHEAR STRENGTH = CONSTANT\*(COMPRESSIVE STRENGTH)<sup>.5</sup>METHOD # 2 :  
-----2 LEVEL(S) OF SHORES  
2 LEVEL(S) OF RESHORES

TIME OF STRIPPING - 1.25 DAYS

TIME OF CASTING - 1.9 DAYS

\*\*\*\*\* END OF METHOD # 2 \*\*\*\*\*

## EXAMPLE # 3

SHORE - RESHORE CONSTRUCTION SCHEDULING ANALYSIS PROGRAM  
-----INPUT DATA :  
-----

TYPE OF CEMENT TO BE USED: TYPE 30

CURING TEMPERATURE IN DEGREE CELSIUS = 0

SPECIFIED DESIGN COMPRESSIVE STRENGTH OF CONCRETE.  
AT 28 DAYS WITH A CURING TEMPERATURE OF 22 C = 40 MPaSPECIFIED CONSTRUCTION COMPRESSIVE STRENGTH OF CONCRETE.  
AT 28 DAYS FOR 0 C CURING TEMPERATURE = 40 MPa

DESIGN CODE USED : CSA

LOADS IN KPa :

LIVE LOAD = 8  
DEAD LOAD = 5  
CONSTRUCTION LIVE LOAD = 2.4

FORMWORKS WEIGHT = .2 OF DEAD LOAD.

TOTAL NUMBER OF FLOORS = 10

THIS ANALYSIS IS BASED ON THE FOLLOWING RELATIONSHIP :  
-----SHEAR STRENGTH = CONSTANT\*(COMPRESSIVE STRENGTH)<sup>.5</sup>METHOD # 2 :  
-----2 LEVEL(S) OF SHORES  
2 LEVEL(S) OF RESHORESTIME OF STRIPPING = 1.84 DAYS  
TIME OF CASTING = 3.17 DAYS

\*\*\*\*\* END OF METHOD # 2 \*\*\*\*\*

## SHORE - RESHORE CONSTRUCTION SCHEDULING ANALYSIS PROGRAM

INPUT DATA :

TYPE OF CEMENT TO BE USED: TYPE 30

CURING TEMPERATURE IN DEGREE CELSIUS - 22

SPECIFIED DESIGN COMPRESSIVE STRENGTH OF CONCRETE,  
AT 28 DAYS WITH A CURING TEMPERATURE OF 22 C - 30 MPaSPECIFIED CONSTRUCTION COMPRESSIVE STRENGTH OF CONCRETE,  
AT 28 DAYS FOR 22 C CURING TEMPERATURE - 55 MPa

DESIGN CODE USED : CSA

LOADS IN KPa :

LIVE LOAD - 5  
DEAD LOAD - 10  
CONSTRUCTION LIVE LOAD - 2.4

FORMWORKS WEIGHT - .1 OF DEAD LOAD.

TOTAL NUMBER OF FLOORS - 10

THIS ANALYSIS IS BASED ON THE FOLLOWING RELATIONSHIP :

SHEAR STRENGTH = CONSTANT\*(COMPRESSIVE STRENGTH)<sup>.8</sup>

METHOD # 2 :

2 LEVEL(S) OF SHORES  
2 LEVEL(S) OF RESHORESTIME OF STRIPPING - 2.1 DAYS  
TIME OF CASTING - 3.8 DAYS

\*\*\*\*\* END OF METHOD # 2 \*\*\*\*\*

APPENDIX 3Hand Calculations of Example no. 1 :Given data:-

1. Type 10 cement,
2. 0° C curing temperature,
3.  $f_c'_{28}$  at 22° C = 25 MPa,
4. Design code used is ACI,
5. Live Load = 6 KPa,  
Dead Load = 4 KPa,  
Const. Live Load = 2 KPa,
6. Formwork weight = 0.1 of the construction live load,
7. No. of floors = 8 .

Method # 2 :

$$\begin{aligned} \text{Equation 1-2 : } U \text{ design} &= D \times (1.4 + 1.7 \text{ LLR}) \\ &= 3.95 \times D \end{aligned}$$

Take U needed (from table 1-2a) = U available

$$\begin{aligned} \text{Equation 1-4 : } U \text{ available} &= U \text{ design} \times (f_{ct}/f_{c28})^P \\ P &= 0.8 \end{aligned}$$

So,

$$f_{ct}(\text{cycle 1A}) = 7.70 \text{ MPa}$$

$$f_{ct}(\text{cycle 1B}) = 10.05 \text{ MPa}$$

$$f_{ct}(\text{cycle 2A}) = 15.92 \text{ MPa}$$

$$f_{ct}(\text{cycle 2B}) = 19.04 \text{ MPa}$$

For 0° C curing temperature, and type 10 cement :

$$f_{ct} = 25 \times 0.106 (t-0.61)/(1 + (t-0.61)) \quad \dots\dots\dots A2-1$$

$$\text{So, } t = f_{ct} / (25-f_{ct}) / 0.106 + 0.61 \quad \dots\dots\dots A2-1a$$

$$t(\text{cycle 1A}) = 4.80 \text{ days,}$$

$$t(\text{cycle 1B}) = 6.96 \text{ days,}$$

$$t(\text{cycle 2A}) = 17.16 \text{ days,}$$

$$t(\text{cycle 2B}) = 30.76 \text{ days.}$$

$$17.16-6.96 = 10.2 > 4.8$$

$$30.76-6.96 = 23.8 > 6.96$$

So, time of stripping =  $17.16/2 = 8.58$  days, and

time of casting =  $30.76/2 = 15.38$  days.

Method # 1:

By using equation A2-1 :

$$f_{c5} = 7.94 \text{ MPa,}$$

$$f_{c7} = 10.09 \text{ MPa,}$$

$$f_{c12} = 13.67 \text{ MPa,}$$

$$f_{c14} = 14.66 \text{ MPa.}$$

By using equation 1-4 :

$$U \text{ available (5)} = 1.58 > 1.54,$$

$$U \text{ available (7)} = 1.91 > 1.90,$$

$$U \text{ available (12)} = 2.43 < 2.75,$$

$$U \text{ available (14)} = 2.57 < 3.17.$$

So, the cycle is not safe.

Method # 1 again :

at 11 days :  $f_c = 13.10$  MPa , and U available =  $2.35 > 1.54$

at 24 days :  $f_c = 17.81$  MPa , and U available =  $3.01 > 1.91$

at 35 days :  $f_c = 19.62$  MPa , and U available =  $3.25 > 2.75$

at 48 days :  $f_c = 20.85$  MPa , and U available =  $3.41 > 3.18$

So, the cycle is safe.

Method # 3 :

The calculations of this method is the same as in method # 1.  
It should be repeated for each possible combinations of no. of shores plus no. of reshores.

## APPENDIX 4

Explanation of SHORE Computer program statements1. Statement # 5 :

To clear and color the screen.

2. Statement # 10 :

Limit the memory spaces.

3. Statements # 160 to 389 :

Input the main data.

4. Statements # 390 to 397 :

Control the print out.

5. Statements # 400 to 480 :

Choosing the method of analysis.

6. Statements # 490 to 560 :

Loads calculations.

LLR = live load ratio = live load / dead load.

CLR = construction live load ratio

= construction live load / dead load.

FL = live load factor = 1.5 for CSA code, and

= 1.7 for ACI code.

FD = dead load factor = 1.25 for CSA code, and

= 1.4 for ACI code.

7. Statements # 580 and 2000 :

Control the methods of analysis.

8. Statements # 581 to 1720 :

Calculations of method # 1.

Statement # 1245 is to control the printing commands of method # 1.

UAVAIL = ultimate load capacity available.

Statement # 1310 is to control the printing out on a hard copy.

NSLABC = no. of slab being cast.

Statements 1590 and 1670 are to avoid printing for type 30 cement.

9. Statements # 1999 to 2220 :

Calculation for method # 2.

Statement # 2080 is to calculate the required strength to give a sufficient load capacity.

10. Statements # 3000 to 3610 :

Calculations for method # 3.

Statements 3245, 3400, 3545, and 3601 are to control the output of method # 3.

11. Statements # 3800 to 3850 :

Trying again in three different methods.

12. Statements # 4000 to 4390 :

Subroutines to display messages and input data.

13. Statements # 4400 to 4550 :

Display the main data to be changed.

14. Statements # 4600 to 4999 :

Control the data changing.

15. Statements # 5000 to 5600 :

Print out the input and output data if a print out on a hard copy has been requested, otherwise to display the output only.

Statements # 5005 and 5007 are to avoid printing the main data again if no changes have been done.

16. Statement # 6000 to 6900 :

Calculate the concrete strength - see chapter 3.

17. Statements # 7000 to 7710 :

Calculate the max load ratio subroutine.

Statements # 7009 to 7015 are to equate all the load ratios 'L' to 1.0. K=1 means cycle A and K=2 means cycle B.

NSTAR = no. of cycle when all the shores are used

(see Fig. 1-1)

Statement # 7106 to change the load ratio values at cycle # NSTAR B if there are no reshores.

NA - 1 = cycle no. until the first floor without supports.

Statement # 7190 is to add the difference 'DF' .

Statement # 7195 is to add the load from the formwork.

Statement # 7210 is to evaluate the load ratios for the last floor at the same cycle.

Statement # 7255 : When K is equal to or smaller than (NFORM+NRESH), then the load ratios at cycle B have the same value at the next cycle (A).

Statements # 7280 to 7310 : start adding  $1/(NFORM+NRESH)$ .

Statements 7510 to 7595 are to factor the load ratios and to multiply by 1.1 for error in theory.

Statements 7600 to 7700 are to find the max values of load ratio (MAX) and at what slab they occur (SLAB).

18. Statements # 8000 to 8700 :

The calculation for maximum load ratios for which no. of shores = 1.

Statements # 8505, 8610, and 8620 are to neglect the error in theory (10%) for which no. of shores = 0.

19. Statements # 9000 to 9700 :

Calculations to find the time for the required strength (see chapter 3.)

Statements 9540 to 9700 are to find the time of stripping and the time of casting.

20. Statements # 9800 to 9830 :

To display a note if  $SU > S$  required.

21. Statements # 14400 to 14595 :

Display all the data to be changed.

22. Statements # 14600 to 15400 :

Control the data changing.