

Computer Aided High Strength Concrete Mixture Proportion using Mat Lab

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ABSTRACT

This paper presents a computer aided mix design for high strength concrete is based on the guideline given in ACI 211.4R-93. Design of concrete mix is extremely complicated since it involves many process and more efforts is required to understand the data given in tables and interpolations also needed frequently when intermediate values are required. Hence the manual process of calculating the mix design may also leads to the human error as the data may be mistakenly handled by the person. The program has been developed and the values have been cross checked with the manual calculation and also have been verified with the various research reports such as mix proportion utilized in (ACI 211-4R-93)(CPA 1995) and also compared with the other mix proportion whose compressive strength is 60 Mpa at 28 days.

Hence the main objective of this paper is to develop a computer aided program to produce the accurate and reliable results within the short period of time and to predict the optimum mix proportion for high strength concrete incorporating silica fume as a partial replacement of cement.

Keywords: Computer aided Mix design, Mat lab, and High strength concrete.

1. INTRODUCTION

Now a day's high strength concrete and high performance concrete are being widely used all over the world. Most applications of high strength concrete have been used in high rise buildings, long Span bridges and some special applications in structures. In developed countries, using High strength concrete in structures today would result in both technical and economic Advantage.^[1]

Development of mix design method plays a key not in concrete technology. It involves the process of determining experimentally the most suitable concrete mixes in order to achieve maximum strength with at least economic expenditures.^[2]

Design of concrete mixes involves determination of the proportions of the given constituents namely, cement, water, coarse aggregate and fine aggregate with admixtures. Workability is specified as the important property of concrete in the fresh state and compressive strength and durability will be considered for the hardened state.

The mix design methods being followed in different countries are mostly based on empirical relationships, charts and graphs developed from extensive experimental investigations. Even though we have several methods are in practice, the method proposed by the American Concrete Institute has been utilized

in this work^[5]. Since ACI Mix design method is an originator for all other methods, including Indian standard method, wherein every table and charts are fully borrowed from ACI.

Based on the experience gathered from the various literatures and also with the reference to (ACI 211 – 4R-93) mix design of HSC has been calculated however the use of this method is a tedious task and since the process is lengthy and it has to refer more number of tables and charts. And, the values must be interpolated based on the data required.

The manual process of calculating the mix design leads to the human error because of improper handling of data and also a time consuming process hence, computer aided mix design of high strength concrete has been developed .

Most of the researcher has used spread sheets for mix design which means that Computation of the ingredients used in concrete using formula without using tables. Apart from all the methods used so far this program has been developed will produce the accurate and reliable results within the short period of time and the values have been cross checked with the manual calculation. Therefore the development of Mat lab coding for HSC is worthwhile.

2. SIGNIFICANCE OF THE RESERCH

In recent times however, that the trend is towards the use of the computer for most computations, a computer-aided approach to the design of concrete mixes is becoming a welcome practice.^[6]

Most of the research publications are available for concrete mix design with different techniques like Regression analysis, Neural network, Fuzzy logic etc. with different types of concrete such as HSC, HPC& light weight concrete, but limited papers have been published especially on HSC, an example of such effort is the computerized mix design^[6] Hence the significance of this research work is to present a paper called computer aided mix design using ACI method for HSC whose compressive strength is M60 which is more simple and reliable.

3. METHODOLOGY

Now-a-days an attempt has been made towards the computer aided mix design. Computational approach and experimental analysis was done with the help of Mat lab.

Based on the method of mix design calculation arrived. The flow chart &algorithm has been developed to show the nature of work as well as detailed outline of the program and also represent the inputs, calculation steps and the output.

3.1 DEVELOPMENT OF A PROGRAM

The mat lab program has been proposed as an alternative solution for solving very tedious problems to find out the best mix proportions. Since there are several techniques available in this concrete technology field comparatively this method is very simple to handle will produce the results such as mix design proportion for the different values.

These mat lab coding is developed by means of simple commands like if and else if .hence the tedious task has been handled flexibly by the given commands. And it does not require much knowledge for the workers about the computer as well about the concrete mix design because by changing the values of the required data itself as an input and after file saved the results will be displayed.

Finally the program has been tested with the different values for different trial mixes. The output received exactly match with the manual calculations. The program consists of three different stages are:

1. Algorithm (coding) & flowchart
2. Restoring the program

3.2 INPUT&OUTPUTDATA

The following data's are required as an input such as:

1. Based on workability (slump value)
2. Maximum size of aggregate.
3. Concrete type (air-entrained concrete or non-air entrained concrete).
4. Mix design method (Weight method or volume method).
5. Compressive strength.
6. Fineness modulus of sand.
7. Oven dry lose weight of coarse aggregate.
8. Specific gravity factor.
9. Percentage of entrained air.
10. Total aggregate volume.
11. Volumes of fine and coarse aggregate.
12. Volumes of normal weight fine aggregate.
13. Dry unit weight of fine aggregate.
14. Dry unit weight of coarse aggregate.

The output produced from the mat lab program is:

1. Water content
2. Water cement ratio
3. Cement content
4. Weight of coarse aggregate
5. Weight of fine aggregate.
6. Water content.
7. Weight of cementious material

3.3 DEVELOPMENT OF PROGRAM

This method developed is to prepare the computer aided mix design for high strength concrete which involved with the algorithm and flow chart (Flow chart-1) is based on steps given ACI mix design method. Based on the method of mix design calculation arrived. The flow chart has been created to show the nature of work as well as detailed outline of the program, which represent the inputs, calculation steps and the output.

Case: 1(Volume method)The design mix of high strength concrete is required to have a compressive strength of 60 Mpa and required slump starts at 50mm , Max size of aggregate used = 12.5 mm; Specific gravity of cement = 3.15;Relative density of fine aggregate (F.A) = 2.59;Relative density of Coarse aggregate (C.A) = 2.76; Dry Rodded Bulk Density of fine aggregate = 105lb/ft³; Dry Rodded Bulk Density of coarse aggregate = 101lb/ft³; with the reference to the previous literature the values have been used and results produce will be converted to normal units .

Case: 2(Weight method)Concrete mix has been designed for HSC to have a compressive strength of 60 Mpa using the following data's such as Slump = 50mm; Maximum size of the aggregate:12.5mm;Specific Gravity of Cement = 3.10;Specific Gravity of Fine Aggregate = 2.65;Specific Gravity of Coarse Aggregate = 2.70;Dry Density of Coarse Aggregate = 1560 kg/m³;Water Cement Ratio = 0.403;Volume of dry rodded Coarse Aggregate = 0.64per unit volume of concrete; Fineness Modulus of Fine Aggregate = 2.40;Fineness Modulus of Coarse Aggregate = 7.20.

Table- 1: Results of mix design (weight method)

Ingredients	Base (manual)	Program results
Cement(Kg)	633	633
Silica fume(Kg)	-	
CA(Kg)	920	920
FA(Kg)	710	710
Water(Kg)	190	190
Air (%)	2%	

Table -2: Results of mix design (Volume method)

INGREDIENTS	BASE(manual)	Program results
Cement(Kg)	435	435.10
Silica fume(Kg)	-	-
CA(Kg)	841.72	841.87
FA(Kg)	676	675
Water(Kg)	190	190
Air (%)	2%	2%

From the table above it is evident that the values calculated using the mat lab coding matches with the manual calculations which means that this program is simple and efficient for mix design computation of high strength concrete for different trial batches

4. CONCLUSIONS

The program has been developed in Mat lab using simple commands such as arithmetic operators, Relational operators & conditional statements. The flow chart gives the detailed outline of the program which specifies the input and output for both absolute volume and weight basis method. An Output of the program have been represented in term of quantity of cement, fine aggregate, coarse aggregate, quantity of water required. And the program has been checked with the same type of problems from the source file. Hence the method of using computer aided techniques which avoids the error formed during calculations mainly in interpolating the data's. Therefore method is more flexible and is used to predict optimum mix proportion for HSC. Thus the program developed with the commands such as if & else if, using mat lab software in a simple way and easily understandable manner and it also serve as a guidelines for beginners. This computer aided mix design developed will make use for high strength concrete to find out exact mix proportions in future without putting more effort.

5. REFERENCES

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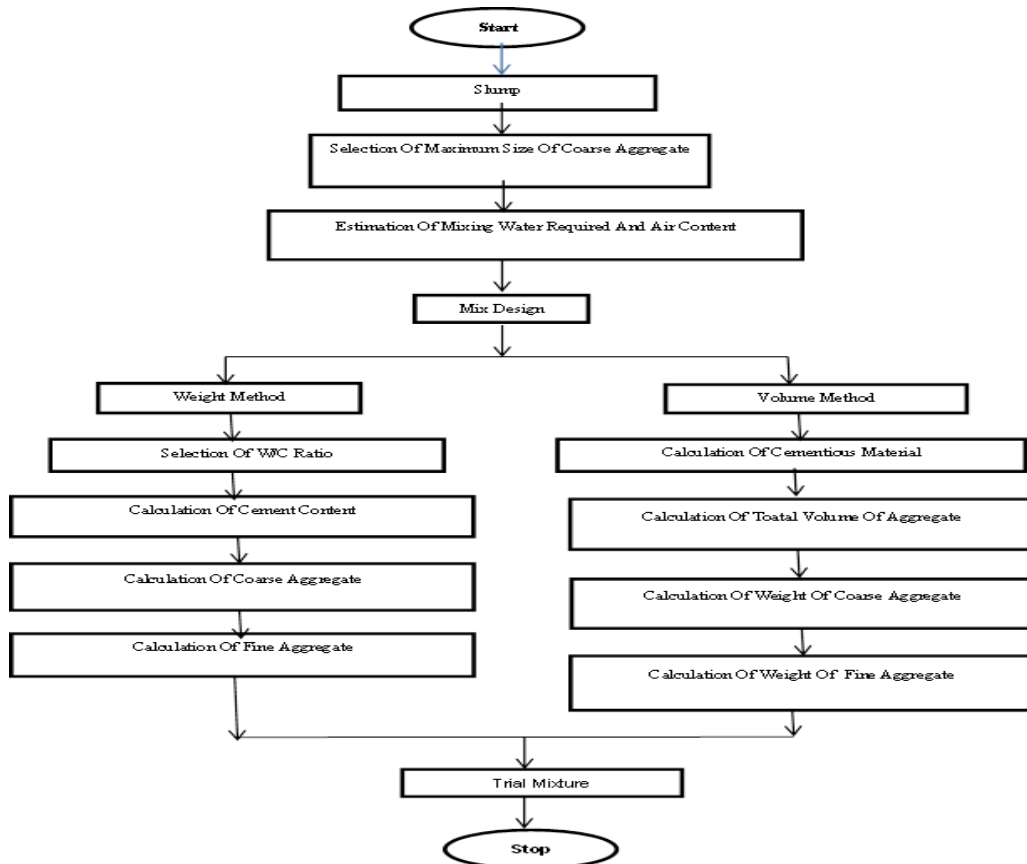
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Fig 1: Flow chart representation of high strength concrete (Both Volume and weight basis)



APPENDIX A:

Mat lab Session for the Mix Design Problems

Case 1: Volume Method

```

clc;
clear all;

% cs=input('compressive strength =');
% slump=input('slump =');
% sgcem=input('specific gravity of cement =');
% sgca=input('specific gravity of coarse aggregate =');
% sgfa=input('specific gravity of fine aggregate =');
% sca=input('size of coarse aggregate =');
% days=input('no. of days (28 or 56) = ');
% hrwra = input('with hrwra -1, without hrwra -0; enter 1
or 0')

cs = 8824;
slump = 2;
sgcem = 3.15;
sgca = 2.76;
sgfa = 2.59;
sca = 0.5;
ae = 2;
days = 28;
hrwra = 1;

% if(cs<=9000)
%   sca = randi([0.75 1],1,1)
% elseif (cs>9000)
%   sca = rand([.375 0.5],1,1)
% end

lock = 0;
fcr = 1.10*(cs)+700;
table1 = xlsread('fractionalvolume.xls')
[m,n] = size(table1);
for i=1:n
    if(lock==0)
        if(table1(1,i) > sca)
            lock = 1;
            temp1 = table1(1,i);
            temp2 = table1(1,i-1);
            temp3 = table1(2,i-1);

```

```

temp4 = table1(2,i);
        fv = (temp4*(sca - temp2) + temp3*(temp1 -
sca))/(temp1 - temp2); % fractional volume of CA
        elseif (table1(1,i) == sca)
            lock = 1;
            fv = table1(2,i);
            % fractional volume of CA
        end
    end
end

mca = fv*101*27; % mass of CA

lock = 0;
table2 = xlsread('amtowater.xls');
[m,n] = size(table2);
for i=2:m
    if(table2(i,1)>=slump);
        for j=2:n
            if(lock==0)
                if(table2(1,j) > sca)
                    lock = 1;
                    temp1 = table2(1,j);
                    temp2 = table2(1,j-1);
                    temp3 = table2(i,j-1);
                    temp4 = table2(i,j);
                    amtw = (temp4*(sca - temp2) +
temp3*(temp1 - sca))/(temp1 - temp2); % mixing water
required
                elseif (table2(1,j) == sca)
                    lock = 1;
                    amtw = table2(i,j);
                    % mixing water required
                end
            end
        end
    end
end

voidfa = (1 - (105/(2.59*62.4))) * 100; % void content
of fine aggregate
mw = (voidfa-35)*8; % mixing water
adjustment

```

```

if (days == 28)
    table3 = xlsread('max_wcm.xls',1);
elseif (days == 56)
    table3 = xlsread('max_wcm.xls',2);
end
[m,n] = size(table3);

for i=2:m-1

    if((table3(i,1)<fcr) && (table3(i+1,1)>fcr));
        for j=2:4
            if((table3(1,j)<sca) && (table3(1,j+1)>sca))

                temp1 = table3(1,j+1);
                temp2 = table3(1,j);
                temp3 = table3(i,j);
                temp4 = table3(i,j+1);
                x = (temp4*(sca - temp2) + temp3*(temp1 - sca))/(temp1 - temp2); % mixing water required

                temp1 = table3(1,j+1);
                temp2 = table3(1,j);
                temp3 = table3(i+1,j);
                temp4 = table3(i+1,j+1);
                y = (temp4*(sca - temp2) + temp3*(temp1 - sca))/(temp1 - temp2); % mixing water required

                temp1 = table3(i+1,1);
                temp2 = table3(i,1);
                temp3 = x;
                temp4 = y;
                z = (temp4*(fcr - temp2) + temp3*(temp1 - fcr))/(temp1 - temp2);

            elseif (table3(1,j) == sca)
                temp1 = table3(1,j+1);
                temp2 = table3(1,j);
                temp3 = table3(i,j);
                temp4 = table3(i,j+1);
                z = (temp4*(sca - temp2) + temp3*(temp1 - sca))/(temp1 - temp2); % mixing water required

                temp1 = table3(1,j);
                temp2 = table3(1,j);
                temp3 = table3(i,j);
                temp4 = table3(i,j+1);
                z = (temp4*(sca - temp2) + temp3*(temp1 - sca))/(temp1 - temp2); % mixing water required

                elseif (table3(1,j+1) == sca)
                    z = table3(i,j);
                    % mixing water required

                end
            end
        end

        temp1 = table3(i+1,1);
        temp2 = table3(i,1);
        temp3 = x;
        temp4 = y;
        z = (temp4*(fcr - temp2) + temp3*(temp1 - fcr))/(temp1 - temp2);

        elseif (table3(i,1)==fcr)
            for j=2:4
                if((table3(1,j)<sca) && (table3(1,j+1)>sca))

                    temp1 = table3(1,j+1);
                    temp2 = table3(1,j);
                    temp3 = table3(i,j);
                    temp4 = table3(i,j+1);
                    z = (temp4*(sca - temp2) + temp3*(temp1 - sca))/(temp1 - temp2); % mixing water required

                elseif (table3(1,j) == sca)
                    z = table3(i,j);
                    % mixing water required

                elseif (table3(1,j+1) == sca)
                    z = table3(i,j);

                end
            end
        end

        wc = z;
        amtcm = amtw / wc;

        pccm = amtcm / (sgcem*62.4);
        pca = mca / (sgca*62.4);
        pw = amtw /62.4;
        pair = (ae/100)*27;
        ptotal = pccm+pca+pw+pair;

        vfa = 27 - ptotal;
        mfa = vfa * sgfa *62.4;

        %mix proportions using silica fume
        sfive = ((5/100)*amtcm);
        sten = ((10/100)*amtcm);
    end
end

```

```

sfif = ((15/100)*amtc);

%mix proportions using silica fume and cement

mcmfive = (amtc-sfive);      % mass of cementious
material for 5percentage of silica fume

mcmten = (amtc-sten);        % mass of cementious
material for 10percentage of silica fume

mcmfif = (amtc-sfif);        % mass of cementious
material for 15percentage of silica fume

%TO FIND THE AMOUNT OF COARSE
AGGREGATE CEMENT

qcemf = mcmfive / (sgcem*62.4);    % 5 mass of
cementious maerial

qcemt = mcmten / (sgcem*62.4);     % 10 mass of
cementious maerial

qcemff = mcmfif / (sgcem*62.4);    % 15 mass of
cementious maerial

%SILICA FUME
%input
sgsf=2.2;    %sgsf specific gravity of silica fume

sffive = sfive/(sgsf*62.4);
sften = sten/(sgsf*62.4);
sffif = sfif/(sgsf*62.4);

%Display mixone
qtotal = qcemf+sffive+pca+pw+pair;

%Display mixtwo
rtotal = qcemt+sften+pca+pw+pair;

%Display mixthree
stotal = qcemff+sffif+pca+pw+pair;

fmfamon = (27 - qtotal);    %fmfa final mass of fine
aggregate for mix one

fmfamt = (27 - rtotal);    %fmfa final mass of fine
aggregate for mix two

fmfamth = (27 - stotal);    %fmfa final mass of fine
aggregate for mix three

%input
%sgfa = 2.59    %rdfa relative density of fine
aggregate

afamixon = (fmfamon*62.4*sgfa);    %acamixon
amount of fine aggregate for mix one

afamixtw = (fmfamtw*62.4*sgfa);    %acamixtw
amount of fine aggregate for mix two

afamixth = (fmfamth*62.4*sgfa);    %acamixthamount
of fine aggregate for mix three

fprintf('cement = %f kg \n',amtc*0.454 );
fprintf('\n mass of fine aggregate = %f kg\n',mfa*0.454);
fprintf('\n mass of coarse aggregate = %f kg
\n',mca*0.454 );
fprintf('\n water = %f kg \n',amtw*0.454 );

fprintf('\n amount of fine aggregate for mix one = %f kg
\n',afamixon*0.454 );
fprintf('\n amount of fine aggregate for mix two = %f kg
\n',afamixtw*0.454 );
fprintf('\n amount of fine aggregate for mix three = %f kg
\n',afamixth*0.454 );

fprintf('\n silica fume for mix one = %f kg \n',sfive*0.454
);
fprintf('\n silica fume for mix two = %f kg \n',sften*0.454
);
fprintf('\n silica fume for mix three = %f kg \n',sfif*0.454
);

fprintf('\n mass of cementious maerial for mix one = %f
kg \n',mcmfive*0.454 );
fprintf('\n mass of cementious maerial for mix two = %f
kg \n',mcmten*0.454 );
fprintf('\n mass of cementious maerial for mix three = %f
kg \n',mcmfif*0.454 );

APPENDIX B: Matlab Session for the Mix
Design Problems
Case 2: Weight Method
clear all;

```

```

clc;
sgc = 3.15;      % Specific Gravity of Cement
sgfa = 2.65;    % Specific Gravity of Fine Aggregate
sgca = 2.70;    % Specific Gravity of Coarse
Aggregate
sgw = 1;
ddca = 1560;    % Dry Density of Coarse Aggregate
wcr = 0.30;    % Water Cement Ratio
mfa = 2.40;    % Fineness Modulus of Fine Aggregate
mca = 7.20;    % Fineness Modulus of Coarse
Aggregate

slump = 100;
fck = 60;
k = 1.65;
s = 5;
sgsf = 2.2      % specific gravity of silica fume

mtcs = fck+(k*s);
sca = 12.5;

table1 = xlsread('tableweightbasis.xlsx',2);
[m,n] = size(table1);
if (slump >= 30 && slump <= 50)
    i=2;
elseif (slump >= 80 && slump <= 100)
    i=3;
elseif (slump >= 150 && slump <= 180)
    i=4;
end
for j=1:n-1
    if (table1(1,j) == sca)
        mwr = table1(i,j);      % mixing water requirement
    end
end
% if((table1(i,1)<sca) && (table3(i+1,1)>sca));
cem = mwr/wcr;

table2 = xlsread('tableweightbasis.xlsx',3);
[m,n] = size(table2);

for x=2:m-1
    if (table2(x,1) == sca)
        i=x;
        end
        end
        for x=2:n-1
            if (table2(1,x) == mfa)
                j=x;
                vdrca = table2(i,j);
            end
        end
        ca = vdrca * ddca;

        vw = mwr/(sgw*1000);
        vc = cem/(sgc*1000);
        vca = ca/(sgca*1000);
        tvfa = 1-(vw+vc+vca);

        qsr = tvfa*sgfa*1000;

        disp('INGREDIENTS      AMOUNT');
        fprintf('Cement      %d\n',cem);
        fprintf('Coarse aggregate      %d\n',ca);
        fprintf('Fine aggregate      %d\n',qsr);
        fprintf('Water      %d\n\n',mwr);

        % disp('% of silica fume      5%      10%
        15%');
        % fprintf('Quantity of sand required      %d      %d      %d \n
        ',qsrp(1),qsrp(2),qsrp(3));

        %amount of cement based on silica fume percentage
        sffive = 0.05*cem;
        sften = 0.10*cem;
        sffif = 0.15*cem;

        cemfive = cem-sffive;
        cemten = cem-sften;
        cemfif = cem-sffif;

        %trial mix one with 5% of silica fume

```

```
vw = mwr/(sgw*1000);  
vctrone = cemfive/(sgc*1000);    % volume of cement for  
trial one  
vsftrone = sffive/(sgsf*1000);    % volume of silica fume  
for trial one  
vca = ca/(sgca*1000);  
tvfatrone1 = 1-(vw+vca+vctrone+vsftrone); %total volume of  
fine aggregate for trial one  
qsr1 = tvfatrone1*sgfa*1000;
```

```
%trial mix one with 10% of silica fume  
vw = mwr/(sgw*1000);  
vctrtwo = cemten/(sgc*1000);    % volume of cement for  
trial two  
vsftrtwo = sften/(sgsf*1000);    % volume of silica fume  
for trial two  
vca = ca/(sgca*1000);  
tvfatrone2 = 1-(vw+vca+vctrtwo+vsftrtwo); %total volume of  
fine aggregate for trial two  
qsr2 = tvfatrone2*sgfa*1000;
```

```
%trial mix one with 15% of silica fume  
vw = mwr/(sgw*1000);  
vctrthree = cemfif/(sgc*1000);    % volume of cement for  
trial three  
vsftrthree = sffif/(sgsf*1000);    % volume of silica fume  
for trial three  
vca = ca/(sgca*1000);  
tvfatrone3 = 1-(vw+vca+vctrthree+vsftrthree); %total volume  
of fine aggregate for trial three  
qsr3 = tvfatrone3*sgfa*1000;
```

```
disp('INGREDIENTS      BASE      TRIAL MIX (1)  
TRIAL MIX (2)      TRIAL MIX (3)');  
fprintf('Cement          %d %d %d  
%d\n',cem,cemfive,cemten,cemfif);  
fprintf('Silica Fume      -      %d %d  
%d\n',sffive,sften,sffif);  
fprintf('Coarse aggregate %d %d %d  
%d\n',ca,ca,ca,ca);  
fprintf('Fine aggregate  %d %d %d  
%d\n',qsr,qsr1,qsr2,qsr3);
```