

Concrete Mix Design by Using Python

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Abstract - This research paper includes the importance of python program in the concrete mix design and code for general mix design of concrete as per IS 456-2000 and IS 10262-2009. It has inclusion of chemical admixture such as fly ash, GGBS, silica fumes and metakaolin. Concrete has a fair share in the modern construction industry having its uses in buildings, bridges, pavements. So, the perfect balance of ingredients in the concrete mix design plays a vital role. With the help of IS code general mix design code of python was compared with the manual mix design calculation.

Key Words: Concrete mix design, admixture, partial replacement, IS code, python

1. INTRODUCTION

Concrete mix design or mistakenly referred as 'cement mix design' comprises of five major elements in different proportion: cement, water, coarse aggregate, fine aggregate (sand), and air. Some elements such as admixture and pozzolanic materials can be included to give it certain desirable properties. Design of concrete mix is done by using IS code tables and calculation provided in the standard. Every grade of concrete has a unique properties and design process. Using python code, mix design for various grades of concrete and combinations of additional materials can be implemented with ease. The work also states the use of mineral admixtures with partial replacement of basic ingredients of concrete.

1.1 Concrete Mix Design

Concrete mix design can be defined as a technique of selecting appropriate elements of concrete and proportioning them to achieve its desired strength. While designing concrete, its objectives like workability, durability, desired strength, cost of material, etc. should be kept in mind. Since mix design of concrete is carried out in accordance with IS code, a lot of criteria need to be fulfilled. In this paper, a simpler way to calculate the quantities of material required for making intended concrete by using programming language named python is presented.

1.2 Use of python in civil engineering

Python, which is known as a vast programming language is becoming efficacious in nowadays technologies. In this

world of emerging technologies, various software are made by using this programming language, and these software are advantageous for the world in the way by making the complex work effortless in lesser time.

At present, like every other field, applications of data science are also involved in civil engineering. Python in this regard is considered to be one of the most in demand and favored programming languages. By using python, we can see a lot of favorable outcomes like:

1. Effective soil simulation and modeling in Geotechnical engineering.
2. Substantial construction management.
3. Correlative design for reinforced concrete structures.
4. Prediction of natural hazards like floods, earthquakes and cyclones for tangible risk evaluation.
5. Concrete mix design by using python.

The reason that python is most in demand and approved programming language is because of its extensive and always upgrading libraries, user-friendly, adaptability, flexibility, and incredible use in the latest technologies. Although, python has immense documentation regarding all the libraries available on the official website for the assistance of python programmers.

Making use of python libraries and python programs a bunch of perks can be gained. These perks include statistical analysis, data analysis, GIS analysis and mathematical analysis. Some problem solving strategies, data interpretation, and manipulation are also including in these perks for better understanding and solving of the problem.

2. MIX DESIGN OF M40 CONCRETE

Step 1) Stipulations for proportioning

- a) Grade of concrete- M40
- b) Cement type – Ordinary Portland cement of grade 43 from IS 269
- c) Mineral admixture type - Fly ash referring from IS 3812 (part-1)
- d) Exposure Condition-Severe (for reinforced concrete)

- e) Maximum nominal size of aggregate-20mm
- f) Workability-120mm (slump)
- g) Admixture type (chemical)-superplasticizer referring from IS 9103
- h) Sp. gravity of cement-3.15
- i) Sp. gravity of Coarse aggregate-2.74
- j) Sp. gravity of fine aggregate-2.65
- k) Sp. gravity of Fly ash-2.2
- l) Zone of Sieve analysis -II
- m) Method of concrete placing-pumping
- n) Degree of supervision -good

Step 2) Target mean strength of concrete

$f'_{ck} = f_{ck} + 1.65s = 40 + 1.65 \times 5 = 48.25 \text{ N/mm}^2$
 Refer IS-10262-2009, table 1, Standard deviation $s=5$, $f_{ck}=40$

Step 3) Selection of Water cement ratio
 For M-40 concrete, maximum w/c ratio=0.45
 Refer IS- 456-2000, table 5.
 $0.36 < 0.45$, hence OK.

Step 4) Water content selection

Confirming to table 4 of IS 10262-2019
 Water content (maximum) (for nominal aggregate size 20mm) =186kg/m³ (for workability of 50mm slump)
 (Increasing water content at the rate of 3% per 25mm slump)
 Estimated water content for 120mm slump
 $= 186 + 8.4/100 \times 186$
 $= 201.62 \text{ kg}$
 Content of water reduced to 23% due to use of superplasticizer at the rate of 1.0% by weight of cement.
 Hence the obtained water content = $201.62 \times 0.77 = 155.25 \text{ kg} \approx 155 \text{ kg}$.

Step 5) Determining cement content

Water-cement ratio= 0.36
 Cement content= $155/0.36 = 430.55 \text{ kg/m}^3 \approx 431 \text{ kg/m}^3$
 Increasing cementitious material by 10 percent based on trials.
 Cementitious material content= $431 \times 1.10 = 474.1 \text{ kg/m}^3 \approx 474 \text{ kg/m}^3$
 Water content= 155 kg/m^3
 Water-cementitious ratio = $\frac{155}{474} = 0.327$
 Adding mineral admixture fly ash that is 30% of total cementitious material content
 $= 474 \times 30\% = 142.2 \approx 142 \text{ kg/m}^3$
 Cement (OPC) = $474 - 142 = 332 \text{ kg/m}^3$
 Corresponding to table 5 of IS 456, for 'severe' exposure condition, the minimum cementitious content is 320 kg/m^3
 $474 \text{ kg/m}^3 > 320 \text{ kg/m}^3$. That is OK.

Step 6) Proportions of coarse aggregate volume and fine aggregate volume content

C.A. volume referring to 20mm size of aggregate and fine aggregate (zone II) for water-cement ratio of 0.50= 0.62; refer table 5 of IS 10262:2019.

Increasing volume of C.A. by 0.346 (at the rate of ∓ 0.01 for every ± 0.05 change in water-cement ratio). Therefore, corrected proportion of volume of CA for the water-cementitious ratio of 0.327= $0.62 + 0.0346 = 0.6546$

Reducing the value by 10 percent for pumpable concrete.
 Volume of coarse aggregate= $0.654 \times 0.9 = 0.5891 \approx 0.59 \text{ m}^3$
 Volume of fine aggregate content = $1 - 0.59 = 0.41 \text{ m}^3$

Step 7) Mix Proportions

For per unit concrete volume,

a) Total volume = 1 m^3

b) Volume of entrapped air in concrete (wet) = 0.01 m^3

c) Volume of cement = $\frac{\text{Mass of cement}}{\text{Specific gravity of cement}} \times \frac{1}{1000}$
 $= \frac{332}{3.15} \times \frac{1}{1000} = 0.105 \text{ m}^3$

d) Fly ash volume = $\frac{\text{Mass of fly ash}}{\text{Specific gravity of fly ash}} \times \frac{1}{1000}$
 $= \frac{142}{2.2} \times \frac{1}{1000} = 0.0654 \text{ m}^3$

e) Volume of water = $\frac{\text{Mass of water}}{\text{Specific gravity of water}} \times \frac{1}{1000}$
 $= \frac{155}{1} \times \frac{1}{1000} = 0.155 \text{ m}^3$

f) Chemical admixture volume (superplasticizer @ 1% by cementitious material mass)

$= \frac{\text{Mass of admixture}}{\text{Specific gravity of admixture}} \times \frac{1}{1000} = \frac{4.74}{1.145} \times \frac{1}{1000} = 0.004 \text{ m}^3$

g) Volume of all in aggregate = $[(a-b) - (c+d+e+f)]$
 $= (1 - 0.01) - (0.105 + 0.0645 + 0.155 + 0.004) = 0.6615 \text{ m}^3$

h) Mass of coarse aggregate = $g \times \text{volume of coarse aggregate} \times \text{Specific gravity of coarse aggregate} \times 1000$

$= 0.6615 \times 0.59 \times 2.74 \times 1000 = 1069.38 \text{ kg} \approx 1069 \text{ kg}$

j) Mass of fine aggregate = $g \times \text{Volume of fine aggregate} \times \text{Specific gravity of fine aggregate} \times 1000$

$= 0.6615 \times 0.41 \times 2.65 \times 1000 = 718.71 \approx 719 \text{ kg}$

Step 8) Mix proportions

Item	Quantity
Cement	332 kg/m ³
Fly ash	142 kg/m ³
Water	110 kg/m ³
Fine aggregate	748 kg/m ³
Coarse aggregate	1085 kg/m ³
Chemical admixture	4.74 kg/m ³
Free water-cementitious materials ratio	0.327

2.1 PYTHON FOR MIX DESIGN

As we know that concrete, to be built at a desired strength requires more strategy of mixing the sand, aggregate and cement with a knowable quantity which is decided after the calculation process. The calculation process is different for various grades of concrete. The calculations, which is the important part of mix design is done by using python programming language in which various simple commands and codes are used.

```
Python 3.4.0 Shell -> C:\Users\24\Desktop\24\per PROJECT\mix design\print.py
File Edit Shell Debug Options Window Help
print('V - CEMENT CONTENT:-')
print(' ')
num11 = float(input("Enter the water cement ratio = "))
num12 = float(input("Enter the water content = "))
CC = num12/num11
formatted111 = '{0:.2f}'.format(CC)
if CC >= 300:
    print("The (CEMENT CONTENT) to be used is= ",formatted111,"Kg/m3")
else:
    print("The (CEMENT CONTENT) to be used is= ",300,"Kg/m3")
print(' ')
print("Types of (MINERAL ADMIXTURE) :-")
print(' |-----|')
print(' | (1) Fly Ash |')
print(' | (2) GGBS (Ground Granulated Blast furnace Slag) |')
print(' | (3) Metakolin |')
print(' | (4) Rice husk ash |')
print(' |-----|')
print(' ')
ch1 = input("If you want to add any (MINERAL ADMIXTURE), then select the (MINERAL ADMIXTURE) from above, else enter [no] = ")
Cmc = CC*1.10
formatted112 = '{0:.2f}'.format(Cmc)
WCR = num12/Cmc
if (ch1 == 'Fly ash') or (ch1 == 'Fly Ash') or (ch1 == 'Fly ash'):
    print("If Fly ash is added then the cement content will be = ",formatted112,"Kg/m3")
```

Fig -1: CALCULATION OF CEMENT CONTENT

In above figure the calculation of cement content is shown, here the mathematical function is used as the cement content is equals to the ratio of Water content/Water cement ratio. If any Mineral Admixture is added, then to increase the cementitious material by 10% for the partial replacement, further multiplication is done for which again a mathematical function is used. Formatted function to reduce the decimal values and character as well as numerical input has assigned for the calculation purpose. After running this code, we can get the value of cement content in the output by entering the values as input according to our Mix Design. A sample of an output of cement content calculation is showed in below figure -2.

```
Python 3.4.0 Shell
Python 3.4.0 (3.4.0.04f714765c13, Mar 16 2014, 19:24:06) [MSC v.1600 32 bit (Intel)] on win32
Type "copyright", "credits" or "license()" for more information.
>>>
-----RESTART-----
>>>
[V - CEMENT CONTENT:-]
Enter the water cement ratio = 0.36
Enter the water content = 155
The (CEMENT CONTENT) to be used is= 430.56 Kg/m3

Types of (MINERAL ADMIXTURE) :-
|-----|
| (1) Fly Ash |
| (2) GGBS (Ground Granulated Blast furnace Slag) |
| (3) Metakolin |
| (4) Rice husk ash |
|-----|

If you want to add any (MINERAL ADMIXTURE), then select the (MINERAL ADMIXTURE) from above, else enter [no] = fly ash
If Fly ash is added then the cement content will be = 473.61 Kg/m3
>>>
```

Fig -2: OUTPUT OF CEMENT CONTENT

3. CONCLUSIONS

There are many changes and reforms in the construction industry. Rapid use of automation has diversified the scope of use of programming languages such as python where complex and recurring calculation by referring IS code can be done quickly and easily. New graduates has advantages over this languages as it improves the analytical skills and problem solving and make them ready for the professional career.

REFERENCES

- [1] Ken W. Day, Concrete Mix Design, Quality Control And Specification.
- [2] IS 456:2000 Concrete Mix Design
- [3] IS 10262:2019 Concrete Mix Proportioning-Guidelines.
- [4] Concrete Technology By MD Shetty
- [5] Purvansh B. Shah, Concrete Mix Design As Per IS Method Of Mix Design
- [6] Sorate Shekhar M. ,Thool Kushal P.,Experimental Investigation On Mix Design Of Concrete By Using IS Method And ACI Method

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