Calculation of Moment of Inertia for various Geometrical cross section using C Programming

Dr. M. Usha Rani

Professor, Department of Civil Engineering, RMK Engineering College, RSM Nagar, Kavaraipettai, Gummidipoondi – 601 206, Tamilnadu, India

---***---

Abstract - *Computer programming is to develop the analytical skills and problem-solving abilities. C programming is a general purpose powerful high level language. Coding is applicable now on almost all industries. In most of design offices today, the calculation routinely performed on computers using software , there by completing the work process easily before the scheduled period. In civil Engineering the modules like Engineering Mechanics, Strength of materials , Structural analysis , Design of Reinforced cement concrete element and Steel structures involves complex Engineering problems. Various steps and empirical formula were followed to perform the analysis and design problems by manual methods . Many times redesign of the section are necessary to satisfy the codal provisions which again consumes more time and Energy. All this can be addressed easily in a programming language very simple and effective way. This paper involves the calculation of Moment of Inertia of various geometrical shapes like circle , rectangle, triangle and the unsymmetrical I section , channel section , T section L section with the basic concept of C programming and condition of If statements. The output obtained by this method is compared with the suitable analytical method.*

Key Words: Area, Centre of Gravity, Moment of inertia, I section, L section, T section , Channel section, c programming.

1.INTRODUCTION

A Structure is composed of slabs , beams and columns. The performance of the structural element depends on many factors such as span, support condition, external load and properties of the materials and cross section. Various geometrical shapes are selected as cross section for the beam and column depending on the design requirements. The selection of the cross section depends on the section modulus which is derived from Moment of Inertia of the section. The product of the elemental area and square of the perpendicular distance between the centroid of area and the axis of reference is the moment of Inertia about the reference axis as shown in Fig.1 It is also called second moment of area. To determine the MOI first we need to determine the centroid of area which is also called as center of gravity where the whole mass is concentrated at the point. The section symmetrical about both axis that is circular, rectangular are selected for span of length 5m. The section symmetrical about one axis that is a most influential section because of the universal benefits and economic in all regions. Such powerful section is only used in all the places irrespective of the load requirement.

1.1 Moment of Inertia of Plane figures

Moment of inertia of a plane figure is generally called as 'area moment of inertia. In SI system of units , units of area moment of inertia are mm4 , cm4, m4 . the moment of inertia denoted by I and carries with it the symbol of the axes about which it is calculated. Thus the moment of inertia about an axis AB denoted by IAB. The moment of inertia about centroidal axes are denoted by IXX and IYY. Again the moment of inertia of simple and composite plane figure are determined separately . The MOI of simple plane figures are determined by the method of integration and the MOI of composite plane figures are determined by applying the theorems of moment of inertia.

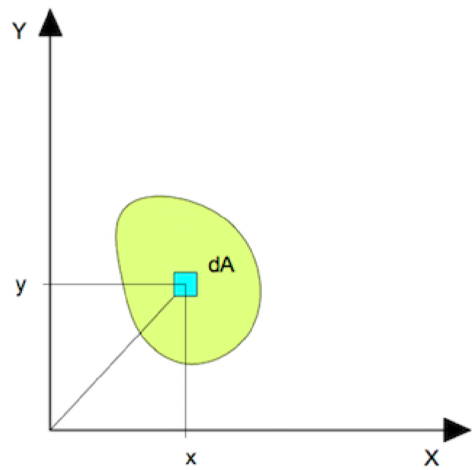


Fig -1: Moment of Inertia

dA = an elemental area

x = Horizontal distance of the centroid of the area from OY axis

y = Vertical distance of the centroid of the area from OX axis

Moment of Inertia of the elemental area about OY axis = area x distance ^{2} = dA x^2

Moment of Inertia of the elemental area about OX axis = area x distance ^{2} = dA y^2

Moment of Inertia of the whole area about OX axis = I_{OX} = $\int y^2\, dA$

Moment of Inertia of the whole area about OY axis =

$I_{OY} = \int x2\, dA$

2. METHODOLOGY:

Preparation of the logic required for the execution of the coding.

↓

Select the Geometrical cross section Section as circular , rectangular ,triangular and unsymmetrical I section ,T, and Channel Section .

↓

Calculation of Centre of Gravity.

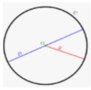
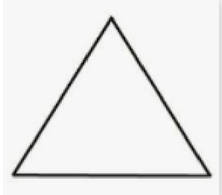
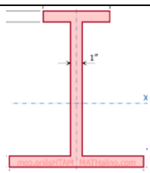
↓

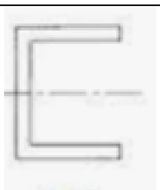
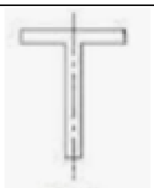
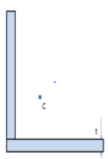
Determination of MOI using Parallel axis theorem

↓

Check the out put with manual calculation

Table -1: Moment of Inertia of Common simple Shapes

Sl.No	Shapes
1	 Circle d= diameter of the circular section a1 – area of circular section g1 = centre of gravity of circular section = d/2 moi1 – moment of inertia of circular section = π x d ^{4} /64
2	 Rectangle w= width of rectangular section h = depth of the rectangular section a2 – area of rectangular section g2 = centre of gravity of rectangular section =h/2 moi2 – moment of inertia of rectangular section = w h^3 / 12
3	 Triangle w= base width of triangular section h = height of triangular section a3 – area of triangular g3 = centre of gravity of triangular section = (1/3) * h from base moi3 – moment of inertia of triangular section = $wh^3/36$
4	 ai, bi = thickness and width of top flange ti , di =thickness and depth of web ci, ei = width and thickness of bottom flange y_{top} = y = Vertical distance of the centroid of the composite section from horizontal reference axix y_{bottom} = (ai, + di + ei,) - yt_{op} I_{xx} = Moment of Inertia of the rectangle about Parallel axis I_{G1} = Moment of Inertia of the rectangle about

	its horizontal centroidal axis $I_{G1} = I_{G2} = I_{G3} = bh^3/12$ A_1 A_2 A_3 = area of the topflange, area of web, area of bottom flange h_1 = vertical distance between the centroid of top flange to the centroid of the composite section. from horizontal reference axis h_2 = vertical distance between the centroid of web to the centroid of the composite section. from horizontal reference axis h_3 = vertical distance between the centroid of bottom of flange to the centroid of the composite section. from horizontal reference axis y_1 = vertical distance of the centroid of top flange from the horizontal reference axis. y_2 = vertical distance of the centroid of web from the horizontal reference axis. Y_3 = vertical distance of the centroid of bottom flange from the horizontal reference axis. $y = ay_1 + ay_2 + ay_3$ / ay $I_{xx} = I_1 + I_2 + I_3$ $I_1 = I_{G1} + A_1 h_1^2$ $I_2 = I_{G2} + A_2 h_3^2$ $I_3 = I_{G3} + A_3 h_3^2$ $h_1 = y - y_1$ $h_2 = y - y_2$ $h_3 = y - y_3$ $I_{G1} = (1/12)\ bd^3$
5	   \\ Channel section T section L -Section

2.1 : Algorithm

Set of statements can be conditionally executed using if statement. Here, logical condition is tested which, may either true or false. If the logical test is true (non zero value) the statement that immediately follows if is executed. If the logical condition is false the control transfers to the next executable statement.

```
if (a==1)
        a1 = (3.14 * d*d )/ (4.0);
        g1 = (d / 2.0);
        moi1= 3.14* ((pow (d,4)) / (64.0)) ;
          if (a==2)
        a2 = (w * h);
        g2 = (h / 2.0);
        printf("g2 %lf \n", g2);
        moi2= w* ((pow (h,3)) / (12.0)) ;
    if (a==3)
        a3 = ((1.0/2.0)* w* h);
        g3 = (1.0 / 3.0)* w*h;
        moi3= w*((pow (h,3)) / (36.0)) ;
  if (a==4)
 ay1 = ( ai*bi)* (( ai/2 ) +(di+ei));
ay2 = (ti *di) * ((di/2) +ei);
ay3  = (ci*ei) * (ei/2);
ay = ( ay1+ay2+ay3) ;
area =  ( ai*bi)+( ti *di)  +( ci*ei) ;
ybottom = ( ay )/( area);
ytop = (ai+di+ei) - (ybottom);
tf = (1.0/12.0);
tf1 = (bi*(pow (ai,3))) * tf;
aotf = (ai*bi);
distance = ((ytop) - (ai/2));
dis1 = 1* pow(distance,2);
mi = (tf) + (aotf *dis1);
tw = (1.0/12.0);
```

```
tf2 = (ti*(pow (di,3))) * tw;

aow = (ti*di);

dw = (((di/2)+(ei))-(ybottom));

dis2 = 1* pow(dw,2);

mow = (tf2) + (aow *dis2);

tbf = (1.0/12.0);

tf3 = (ci*(pow (ei,3))) * tbf;

abf = (ci*ei);

dbf = ((ybottom) -(ei/2));

dis3 = 1* pow(dbf,2);

mbf = (tf3) + (abf *dis3);

totalmoi= (mbf +mi+mow);
```

Output:

```
1. circle

 2. rectangle

3.  triangle

 4. I unsection

 4    Enter the  value:20 60 20 60 100 20

ybottom, ytop: 42.72    57.27    tf1: 40000

distance: 47.27

dis1: 2234.71

tf1, aotf,dis1,mi: 40000.0,1200.0 ,2234.71, 2681652.75
tf2: 360000.00

dw: 7.27

dis2: 52.89

tf2, aow,dis2,mi:
360000.0,1200.00,52.892570,423471.093750tf3:
66666.671875

dbf: 32.727272

dis3: 1071.074341

tf3, abf,dbf,mbf:
66666.671875,2000.000000,1071.074341,2208815.50000
totalmoi:5313939.000000
```

3. CONCLUSIONS

The output result of MOI of unsymmetrical I section are presented here. It was observed that the output results are exactly same as the manual calculation. Similarly in a single programme the results of MOI of Channel section , T section , L section is possible to get by entering the thickness and width of the flange and web. The manual method is time consuming and involves repetitive calculations. Hence it is better to use C programming code to easily to get the result with minimum time.

REFERENCES

[1] Anita Goel, Ajay Mittal , Text Book on Computer Fundamentals and Programming in C, 2016, Pearson India Education Services Pvt. Ltd

[2] Rajasekaran S and Sankarasubramanian G., Text Book on Engineering Mechanics Statics and Dynamics||, 3rd Edition, Vikas Publishing House Pvt. Ltd., 2017.

AUTHOR

Dr.M.Usha Rani working as Professor in civil Engineering Department, at R.M.K. Engineering College, RSM Nagar, Kavaraipettai, Gummudipoondi, Thiruvallur District, Tamilnadu, India