Automatic Design of various Reinforced Concrete Structures based on AutoCAD AutoLISP

Dharani V P[1], Parvatham Vijay[2]

[1]Department of Civil Engineering, Thiagarajar College of Engineering, Madurai, India. [2]Department of Electronics and Communication Engineering, Sri Sai Ram Institute of Technology, Chennai, India.

[1]dharanivp@student.tce.edu, [2]parvathamvijay_73@yahoo.co.uk

Abstract –

The objective of this paper is to develop different automatic designs for building construction using a new tool called AutoCAD AutoLISP. One-way slab, Reinforced Cement Concrete pipe, straight stairs spanning horizontally, Circular tank over the ground and a Square Column Footing. These are the designs developed using AutoLISP software. Five Library functions are developed to get the 3D model for these designs. After getting the input parameters from the user, the required design structure will be generated automatically. The advantage of this tool is that since the library is created, the import of drawings in the structural analysis will be easy; it will shorten the design period compared to other software. Developing all types of slabs, stairs and tanks using this software will be more beneficial to improve the design efficiency and quality.

Keywords –

Automatic; Design; Reinforced; Concrete; structures; AutoCAD; AutoLISP.

1 Introduction

Software has been developed for the design and drafting of reinforced concrete structures. The reinforcement sketches given by many of such software are of a standard fixed format. Therefore, structural designers could not modify its format as per their requirements. Preparing drawings manually is a tedious and time- consuming work and may also have manual errors. Hence, there is a need for a program that can be easily customized as per the individual's choice and generates the required design in the form of intuitive 3D design automatically.

Automation in design has been used in modern industries and design enterprises. In chemical industry applications, with the help of AutoCAD Visual Basic Applications, a program has been developed which can automatically generate the 3D model of trough-type liquid distributor as per design parameter input [1]. In manufacturing industry applications, with the help of AutoCAD customization, the automatic generation of a model of milling of a gear wheel has been developed, where the impact of cutting parameters on the tooth form of a manufactured wheel is examined. [2]

For computer aided drafting, AutoCAD is widely used. Therefore, a program that can customize AutoCAD rather than an independent package is needed as all other drawings are prepared in AutoCAD, such as Layout plans, schedules, Notes etc. AutoLISP can be used to write customized programs which control virtually every aspect of drawing and database [3]. AutoLISP program is used to automatically generate geometrically accurate computer 3D models of gear drives and hob cutters [2]. AutoLISP program is used in the Simulation of the Processing of a Helical with the aid of a frontal-cylindrical milling tool. [4]

2 About AutoLISP

AutoLISP is a unique language specially designed for AutoCAD automation [5]. AutoLISP programs perform functions by connecting points in the 3D graph by objects. For example, adding length to the X-coordinate of a point and then adding width to the Y-coordinate of the formed point forms an L shape. Simple mathematical operations and loop functions can be incorporated into AutoLISP programs. Using AutoLISP, programs can be written to generate the automatic 3D designs of any structural member or even a complete structural design of a building like a security cabin. The following sections explain the design automation process for one-way slab, RCC pipe, straight stairs spanning horizontally, circular tank over ground and square column footing.

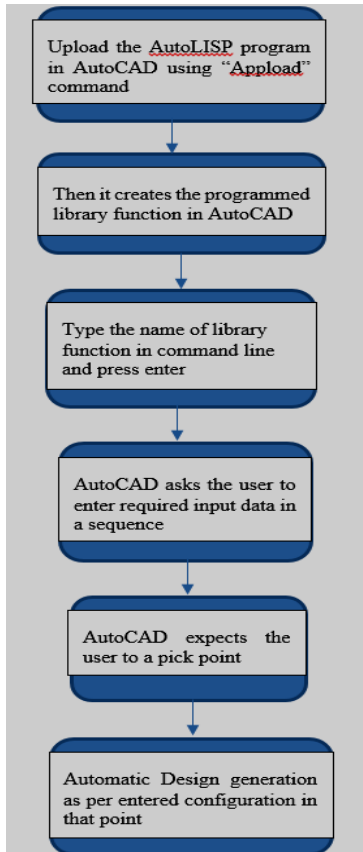### 2.1 Functioning of Program

Flowchart representation

Figure.1. Flow chart

3 Automatic design of straight stairs

Straight stairs are provided in a long narrow stair case. It often consists of one flight. The library function created can generate a 3D design of single- flight straight stairs spanning horizontally as per the dimensional parameters provided by the user [6].
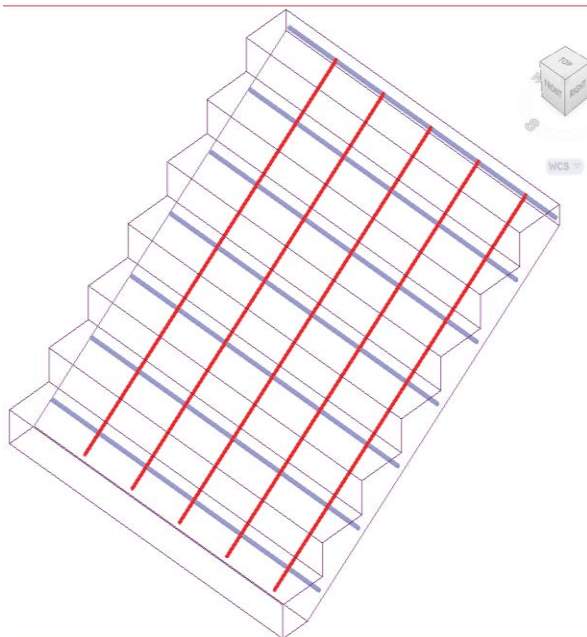

Figure 2. Design output for straight stairs

Table 1. Design parameters for straight stairs

serial number	Parameter	Values in millimeter
1	length of riser	Need input
2	length of thread	Need input
3	span of stair slab	Need input (<1500)
4	wall or beam thickness on either side of slab	Need input
5	Diameter of main bars	6
6	Diameter of distribution bars	10
7	Thickness of waist slab	80
8	Number of steps	Need input

4 Automatic design of one-way slab

Slabs form floors and roofs of buildings. Consider a slab panel supported on all four sides. If the ratio of the long span to the short span is greater than 2, such a slab is considered a one-way slab [7]. The library function created in AutoCAD can automatically generate the design of reinforcement detailing of the slab after giving all the input parameters.

Table 2. Design parameters for one-way slab

| serial number	Parameter	Values in millimeter
1	Long span of slab	Need input
2	Short span of slab	Need input
3	Beam thickness	Need input
4	Clear cover distance for main bars	Need input
5	Diameter of main bars	Need input
6	Diameter of distribution bars	Need input
7	Length of crank in main bars	Need input
8	Centre to Centre spacing of main bars	Need input
9	Centre to Centre spacing of distribution bars	Need input
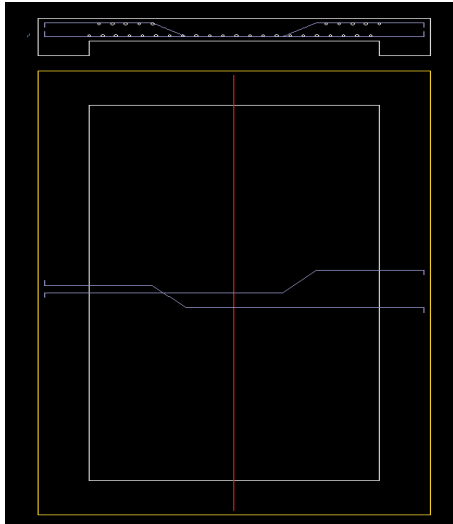
Figure 3. Design output for one-way slab
(Cross section and plan of slab)

5 Automation in design of RCC pipe

Reinforced concrete pipes are generally used for carrying water in the water supply systems, carrying wastewater or storm water and conducting small streams or drains under embankments. This library function automatically generates the reinforcement detailing for the RCC pipe after getting input from the users (table 3).

Table 3. Design parameters for RCC pipe

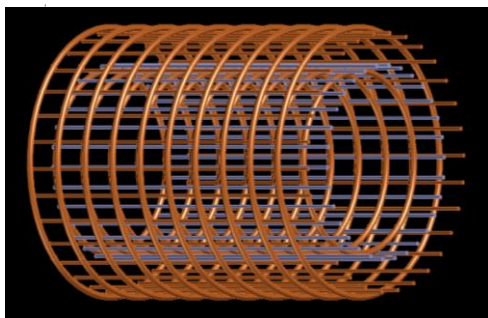| serial number	Parameter	Values in millimeter
1	Diameter of pipe	Need input
2	Thickness of pipe	Need input
3	Diameter of bars in vertical reinforcement	Need input
4	Diameter of bars in hoop reinforcement	Need input
5	Pitch of hoop reinforcement	Need input
6	Length of pipe	Need input

Figure 4. Design output of RCC pipe reinforcement

6 Automation in design of circular tank

A reinforced concrete tank is a very useful structure meant for storing water, for swimming baths, sewage sedimentation and similar purposes. This library function automatically generates the reinforcement detailing for a circular tank on the ground and open to the atmosphere after getting the required input from the users. The joint is flexible between the base and reinforcement. In base, the top and bottom mesh is designed and if the ring beam is required, its design is also generated automatically.

Table 4. Design parameters for circular tank having non-monolithic walls and base slab

| serial number	Parameter	Values in millimeter
1	Diameter of tank	Need input
2	Diameter of bars in top and bottom mesh in base slab	10
3	Diameter of bars in vertical reinforcement	Need input
4	Thickness of wall	Need input
5	Thickness of base slab	Need input
6	Diameter of bars in hoop reinforcement	Need input
7	Centre to Centre spacing of bars in mesh	250
8	Pitch of hoops	Need input
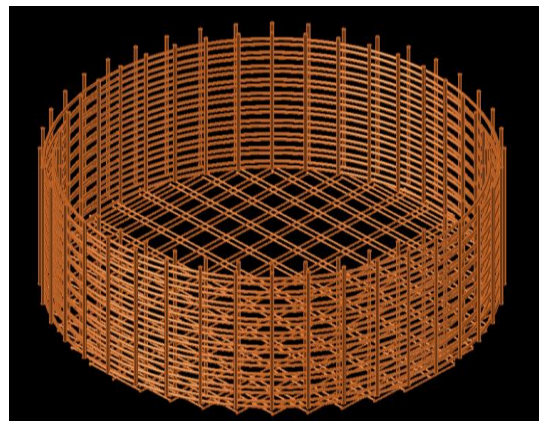
Figure 5. Design output of circular tank reinforcement

7 Automatic Design of Square Column Footing

Square column footing is a type of shallow foundation in which the base of a wall or column is sufficiently enlarged to act as individual support. The

widened base provides stability and is useful in distributing the load on sufficient soil area. This library function automatically generates the three-dimensional design of square column footing after getting the required input data from the users (Table 5). After giving all the inputs, the user has to pick a point for inserting the design. This action will plot the design in the AutoCAD window following the configurations provided by the user, as shown in Figure 6. This design can be easily edited by using AutoCAD drawing commands.
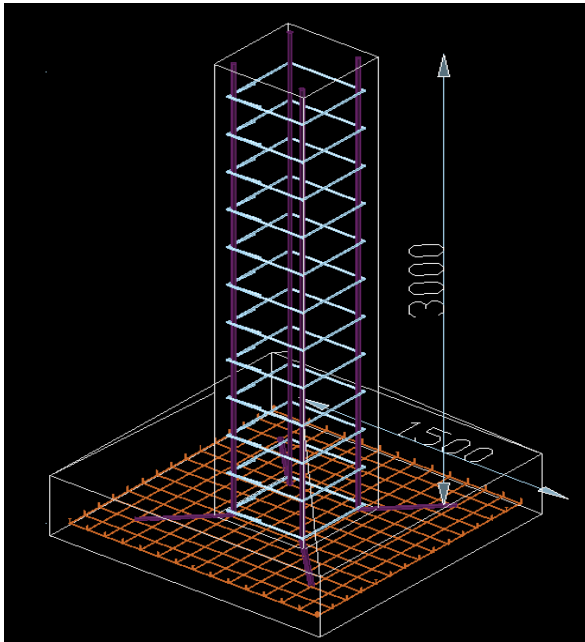

Figure 6. Design output for square column footing

Table 5. Design parameters for square column footing

serial number	Parameter	Values in millimeter
1	Side length of footing	Need input
2	Total depth of footing	Need input
3	Reduced depth of footing	Need input
4	Number of bars in footing reinforcement in principal direction	Need input
5	Diameter of bars in footing reinforcement	Need input
6	Diameter of longitudinal bars in column reinforcement	Need input
7	Pitch of lateral ties	Need input
8	Diameter of lateral ties	Need input
9	Side length of column	Need input
10	Clear cover for footing reinforcement	Need input
11	Clear cover for column reinforcement	Need input

8 Conclusion

This tool will be handy for structural and design engineers since the design gets generated automatically after feeding input parameters. The dimensional parameters gained after performing engineering calculations for specific structure has to be entered into this tool which has a set of library functions. Then, it generates the required 3D intuitive design within a minute. This tool helps to focus on more creative design, improving design efficiency and quality, shortening product design period. Being very useful in product design, it can be used for more and more specialized design and development. By developing all types of slabs, stairs, foundations and tanks using this software, perfection in design can be maintained in our day-to-day structural design of buildings.

References

[1] Pengfei Zhang and Luojia Wan. 3D Parametric Design on Trough Type Liquid Distributor Based on AutoCAD VBA. In *international conference on information and computer application,* pages 524–530, Hong Kong, China, 2012.

[2] Kheifetc A. L. Geometrically Accurate Computer 3D Models of Gear Drives and Hob Cutters. In *International Conference on Industrial Engineering,* pages 1098 – 1106, South Ural State University, Russia, 2016.

[3] Poleshchuk N. *AutoCAD Developer's Guide to Visual LISP*, First Indian edition. Eswar Press, "Archana Arcade" No. 16/8, Natesan Street, T.Nagar, Chennai, India, 2003.

[4] Sorin Cristian Albua. Simulation of Processing of a Helical with the aid of a frontal-cylindrical milling tool. In *The 12th International Conference Interdisciplinarity in Engineering,* pages 36–41, 2019.

[5] George O. Head. *AutoLISP In Plain English*, Second edition. Galgotia Publications pvt. ltd, 5, Ansari Road, Daryaganj New Delhi, India, 1990.

[6] Code of Practice for Plain and Reinforced Concrete, Bureau of Indian Standards, IS456:2000, Manak Bhavan, New Delhi.

[7] Ramamrutham S. *Design of Reinforced Concrete Structures*, Seventeenth Revised and enlarged edition. Dhanpat Rai Publishing Company, New Delhi, India, 2010.