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Flexural Analysis of Rainforced Concrete Precast Curb Stone of Colored Cement

Dr. Hamid Abdul Mahdi Faris
Environmental Engineering Department, Al Mustansiriya University, Baghdad, Iraq

ABSTRACT

In this research, a new design is proposed for the (Curbstone). In this design, the curbstone is hollow from the inside and not a hard stone, as in the old design. The new design has many advantages. The quantities of casting material will be supplied. Water pipes, electric wires and optical cables through which will be dispensed with digging the pavement to pass it and can also drain rain water through the cavity. The Ferro cement was used to make the new pavement stone. Four models were poured and tested using two-toned Ferro-cement, two with small stones, and reinforcing steel was used to increase durability. The results of the examination of the four models showed that they carry more than the old curbstone bearing mentioned in the Iraqi standard.

Keywords : Flexural Analysis Precast Concrete Curb Stone , Water Pipes, Electric Wires, Optical Cables, AASHTO, Austroads GRD

I. INTRODUCTION

Curb stone have a significant effect on driver behaviour. Curb stone affects the distance that drivers align their vehicles from the edge of a road and acts as a physical and psychological barrier that discourages them from leaving the road surface. Generally lateral placement of vehicles varies with curb stone height and steepness as well as the location of other obstructions outside the curb stone -line. Curbing improves delineation of road edges and contributes to the appearance and safety of the road.

The main purposes for curb stone construction are:

- ✓ To assist drainage.
- ✓ To improve channelization and delineation of traffic flows.
- ✓ To protect pedestrians.
- ✓ Improvement of aesthetic values of the road alignment.
- ✓ To reduce maintenance of shoulders.
- ✓ To provide a boundary to landscaping treatments.

The use of kerbing to control vehicle movements is generally recommended in urban environments particularly at intersections because it is most effective at low speeds and small angles of impact. Kerbing is not recommended on rural roads and on high-speed roads, unless specifically required to improve channelization at rural intersections, to control drainage in cuts, on bridges etc.

Construction of kerbing may significantly affect the cost of a project. Therefore, construction of kerbing should be justified in the following situations:

1. Limited road reserve (introduction of kerbing reduces the cross-section width).
2. Deep cuttings (to assist drainage).
3. Special environmental requirements (control accidental spills, drainage of bridges etc.).
4. Structural requirements (to protect high embankments from scouring)

1.1 TYPE of curb stone

The two basic classes of curb stone are barrier and mountable curb stone. Each class has different types including semi-mountable and semi-barrier curb stone with a variety of designs. Dimensions of the most common types of curbing used on Western Australian roads

1.1.1 Barrier curb stone

Barrier curb stone are steep-faced and are designed to prevent vehicle encroachment on the roadside. Their main functions are

To discourage vehicles from using areas outside the travelled way, not intended for vehicular travel;

To control drainage;

To control parking of vehicles;

To reduce the risk to pedestrians.

The typical barrier curb stone is 150mm high. This height is effective to prevent vehicle encroachment into the roadside at low to moderate speeds.

Barrier and semi-barrier curbing should generally be avoided on freeways or highways with design speeds of over 70 km/h because impact with curbing on high-speed roads may overturn a vehicle or result in a vehicle becoming airborne.

Barrier-type curb stone may be used on sections of road where separation of opposing traffic is essential due to the high safety risks associated with traffic volumes, percentage of heavy vehicles, speed, crash history etc.

If a design allows for curbed shoulders with barrier type curbing the shoulder width should be adequate to accommodate a disabled vehicle (eg. AASHTO recommends a min of 1.8m; Austroads recommends a minimum width of 2.0m). The desirable shoulder widths for rural and outer urban roads are shown in Main Roads Supplement to Austroads GRD Part 3: Geometric Design – Table 4.3.

Barrier curb stone, if positioned along the edge of a traffic lane, gives drivers a sense of restriction. Also large vehicles travelling along curbed carriageways have no additional space in which to manoeuvre or to allow for sway of the rear trailer. It is recommended to avoid this type of curbing on roads with restricted lane width and high percentage of heavy vehicles.

Barrier curb stone reduce the risk to pedestrians, not only as a physical but psychological barrier as well, because drivers generally tend to shy away from the curb stone line. For this reason, barrier curbing is recommended in built-up areas adjacent to footpaths with considerable pedestrian traffic, shared use paths and also at bus bays.

Barrier-type curb stone may be used on low speed (< 70 km/h) arterial roads in order to prevent mid-block turns.

Some of the above text was adopted from AASHTO's Policy on Geometric Design of Highways and Streets (2004).

Figure 1.1: Barrier curb stone

1.1.2 Semi-Barrier curb stone

This type of curbing is recommended where pedestrian traffic is light and a barrier type could tend to reduce traffic capacity due to the impression of restriction.

Figure 1.2: Semi-Barrier curb stone

1.1.3 Mountable curb stone

Mountable curb stone (Type A and M) are generally used in the following situations:

At the outer mountable island area of intersections, small corner islands and roundabouts to outline standard vehicle travelled paths.

To define the left edge of a through carriageway where the cross fall of the adjacent shoulder or parking strip is opposite to that of the through carriageway.

Where crossing or encroachment by vehicles larger than the design vehicles is permitted (e.g. at roundabouts) or expected under emergency conditions.

In front of road safety barriers.

On pedestrian and cycle paths along the grassed edge of asphalt paths to reduce damage to the path from the grass growing into the asphalt path. Curbing along paths also provides visual contrast to the path edge and prevents the verge material erosion onto the path.

Flush type curb stone (refer to Type M in Figure 1) are generally used in the following situations:

On lightly travelled residential streets because it does not require modification at driveway entrances.

The design of mountable curb stone should not result in loss of vehicle control or undercarriage damage when struck.

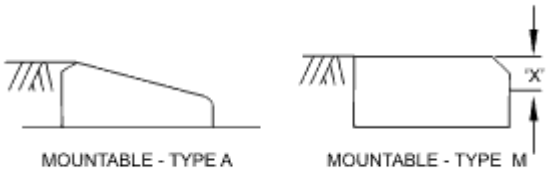

Figure 1.3: Mountable curb stone (Type A and M)

1.1.4 Semi-Mountable curb stone

Semi-mountable curb stone should be used at all intersections, junctions and island treatments and is often used on outer separators and raised medians on curb stone. Semi-mountable curb stone may also be used along pedestrian and cycle paths.

Figure 1.4: Semi-Mountable curb stone

1.1.5 Other

The following types of curb stone are used to enhance the visibility/perception of a road alignment:

High-visibility curbing may be specified by a designer in areas where visibility is restricted due to fog or

extended rains. For this purpose white marking or white cement may be used as per AS 1742.2 – 1994.

Reflective curb stone use retro-reflective markings to improve visibility/perception. They are advantageous at night if placed along through-lane edges and island curb stone at intersections with high percentage of night-time crashes.

Where such alternative curb stone types are proposed to be used on roads managed by Main Roads, approval from the Main Roads Project Manager shall be obtained.

2. EXPERIMENTAL PROCEDURE

2.1 Introduction

In order to study the flexural behaviour of Ferro cement concrete curb stone four different models were made of the curb stone and the following differences is:

- Mixture type by using

- simple mixture consists ratios of 4 sand and 2 cement sand and 1.5 water only sample (A_1 , A_2)

- While the second mixture is concrete mix consists ratios of 4 Aggregate and 2 sand and 1 cement and 0.75 water sample (B_1, B_2)

And also we use two different dimensions sample (A1=, B_1) the larger models and sample (A_2, B_2) the small models. Show in (Figure 2.1)

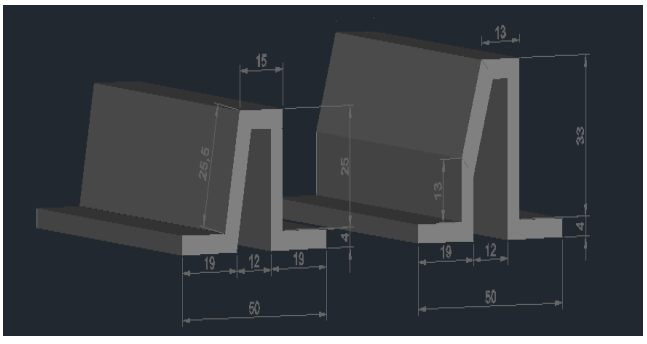

Figure 2.1: shape of curb stone we use

2.2 Quantity of materials used in models:

- Simple mixture curb stone sample (A1) show in Table 2.1

material	Volume(L)
Sand	50 L
Cement	25 L
Water	18.75 L
Total	93.75 L

Table 2.1: Quantity of sample (A1)

- Simple mixture curb stone sample (A_2) show in Table 2.2

Material	Volume(L)
Sand	40 L
Cement	20 L
Water	15 L
Total	75 L

Table 2.2: Quantity of sample (A_2)

- Concrete mix curb stone sample (B_1) show in Table 2.3

Material	Volume(L)
Grit	50 L
Sand	25 L
Cement	12.5 L
Water	5 L
Total	92.5 L

Table 2.3: Quantity of sample (B_1)

- Concrete mix curb stone sample (B_2) show in Table 2.4

Material	Volume(L)
Grit	40 L
Sand	20 L
Cement	10 L
Water	3 L
Total	73 L

Table 2.4: Quantity of sample (B_2)

2.3 The reinforcement

The reinforcement type was from Steel bar and Steel Mesh

We use 7 Steel bar and 2 Layers of Steel Mesh

Figure 2.2: Steel bar

Two different Shapes reinforcement we use in work

- The First Shapes we use 7 Steel bar (8mm) horizontal to Width and 2 Layers of Steel Mesh surrounds the Steel bar's show in (Figure 2.2)

Figure 2.3: shape of First reinforcement

- The Second Shapes we use 4 Steel bar horizontal to Width , 3 Steel bar Perpendicular to Width and 1 Layers of Steel Mesh surrounds the bar's show in (Figure 2.3)

Figure 2.4: shape of Second reinforcement

2.4 Casting

We Casting the models using a wooden mold show in Figure 4.4 and in quantities mentioned in paragraph (2.2 Quantity of materials used in models) with vibration to homogenize materials with reinforcement

Figure 2.5: wooden mold

2.5 Curing

Proper curing is necessary to develop the required properties of the mortar. We curing for 28 days, curing in the first two weeks is essential and should start 24 hours after final application of the mortar to avoid shrinkage cracks

3.1 Design benefits

You can take advantage of the space in the design:

1- Space can be used to connect electrical and connections cables instead of Buried in the ground, the cost will be reduced because you do not need to dig the ground but put it directly in the space, we have Merge the two projects into one project and the cost will be less.

2- Space can be used for rainwater drains through the design shown in (Figure 3.1), we do not need to make rain streams We will benefit from Merge the curb stone with rain streams by reducing cost and time Of the project, We can do different diameter of the stream from 12 mm to 50 mm Depending on the discharge of Rainfall.

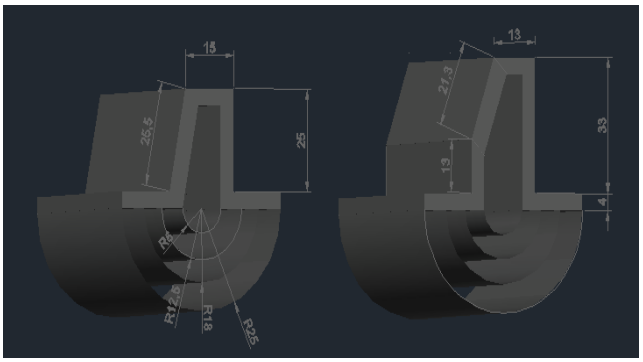

Figure 3.1:

3.2 Economic Advantages of use Ferro-concrete

The economic advantage of Ferro concrete structures is that they are stronger and more durable than some traditional building methods. Depending on the quality of construction and the climate of its location, houses may pay for themselves with almost zero maintenance and lower insurance requirements. Water tanks could pay for themselves by not needing periodic replacement, if properly constructed of reinforced concrete.

Ferro concrete structures can be built quickly, which can have economic advantages. In inclement weather conditions, the ability to quickly erect and enclose the building allows workers to shelter within and continue interior finishing.

In India, Ferro concrete is used often because the constructions made from it are more resistant to earthquakes. Earthquake resistance is dependent on good construction technique and additional reinforcement of the concrete.

In the 1970s, designers adapted their yacht designs to the then very popular backyard building scheme of building a boat using Ferro-cement. Its big attraction was that for minimum outlay and costs, a reasonable application of skill, an amateur could construct a smooth, strong and substantial yacht hull. A Ferro-cement hull can prove to be of similar or lower weight than a fiber reinforced plastic (fiberglass), aluminium, or steel hull. New methods of laminating layers of cement and steel mesh in a mold may bring new life to Ferro-cement boat-building. A thorough examination of reinforced concrete and current practice would benefit the boat builder. An example of a well-known Ferro-cement boat is *Hardiesse*, the Falmouth sail-training ship.

There are basically three types of methods of Ferro-cement. They are following

1. Armature system: In this method the skeleton steel is welded to the desired shape on either of sides of which are tied several layers of stretched meshes. This is strong enough, so that mortar can be filled in by pressing for one side and temporarily supporting from the other side. Filling in of mortar can also be administered by pressing in the mortar from both the sides. In this method the skeletal steel (bars) are at centre of the section and as such they add to the dead weight of without any contribution to strength.
2. Closed mold systems: Several layers of meshes are tied together against the surface of the mold which holds them in position while mortar is being filled in. The mold may be removed after curing or may remain in position as a permanent part of a finished structure. If the mold is to be removed for reuse, releasing agent must be used.
3. Integrated mold system: Using minimum reinforcement any integral mold is first to be considered to act as a framework. On this mold layers of meshes are fixed on either side and plastering is done onto them from both sides. As the name suggests, the mold remains permanently as an integral part of the finished structure. (E.g. double T-sections for flooring, roofing etc.) Precaution should be taken to have firm connection between the mold and the layers filled in later, so that finished product as a whole integral structural unit.

4. Test of curb stone

We tested the models by shedding pressure force (KN) until the sample have first Crack by the third beam load Machine shoe in Figure 4.1

Figure 4.1: the third beam load Machine

The following readings were obtained from the examination indicated in Table 4.1

Sample	pressure force (KN)
A_1	54.78 KN
A_2	55.84 KN
B_1	50.05 KN
B_2	55.67 KN

Table 4.1: Readings

Figure 4.2: first Crack simple A_2

Figure 4.3: first Crack simple A_1

4.2 Results

We will calculate the results by the following law:

$$Fr = \frac{P \times L}{b \times n^2} \times \frac{3}{2}$$

Where:

Fr = Crushing coefficient (N/mm²)

P = the force at which the sample fail (N)

L = the distance between the two points of focus (mm)

b = the large rib of the sample section (mm)

n = the small rib of the sample section (mm)

-The Min Crushing coefficient According to Iraqi specifications number (1106) for a year (1987) is (3.5 N/mm²)

So the readings as follow:

$$Fr(A_2) = \frac{55840 \times 94}{100 \times 95.5^2} \times \frac{3}{2}$$

$$Fr(B_1) = \frac{50050 \times 94}{100 \times 106.3^2} \times \frac{3}{2}$$

$$Fr(B_2) = \frac{55670 \times 94}{100 \times 95.5^2} \times \frac{3}{2}$$

Sample	Crushing coefficient (N/mm²)
A_1	6.84
A_2	8.63
B_1	6.25
B_2	8.61

4.3 Conclusion and Recommendation of this Study

Based on the comprehensive review of literature, the following are the inferences drawn:

1- As result of this research, it turns out that this design is successful and can work because it passed the tests successfully and a large difference from the Iraqi specifications number (1106) for the year (1987).

2- The difference between the samples (A1 and B_1 is 0.59(N/mm²)) but the difference Very small between (A2 and B_2 is 0.02 (N/mm²))

3- Sample A2 and B_2 Much better From A_1 and B_1 Because of the large difference in design measurements and distribute the pressure exerted on it

4- Use the wooden mold is not practical , because if the use more than once It will be damaged by water

and Excessive pressure of hardening mixture , so we use Iron mold Much better and can be used more than once.

5- The Ferro-cement structures are thin and light-weight compared to conventional reinforced concrete. Hence there is considerable reduction in self-weight of the structure and saving in foundation cost. Transportation cost is also less.

6- Ferro-cement construction is simple and quick and does not require highly skilled labor; and the laborers can also be easily trained for this job. Also it does not require any heavy equipment / machinery for casting or lifting purposes. It is an economically feasible material and also suitable for developing countries in both urban and rural areas.

7- The new Curbstone is most suitable for water-retaining structures due to water-tightness and impermeability.

8- The new Curb stone structures can be easily maintained, and also repaired in the event of structural damage without any major problems.

9- should be caution to mix the cement mortar and apply to the reinforcing mesh as per the required technical specifications, and more emphasis should be paid in selection of a richer cement-sand ratio and lower water-cement ratio for the Ferro manoeuvre cement mortars, as specified by the ACI Codes.

10- This study also recommends that fibers may be added as additional reinforcement in Ferro cement into the matrix composition for crack-control and resistance against local loads. Synthetic fibers (such as nylon, poly-vinyl chloride, polyolefin, polyvinyl alcohol, polyethylene and polypropylene) can be used in Ferro cement instead of steel fibers so as to avoid corrosion.

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