# Design and Fabrication of Gutters

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**Abstract -** *To achieve the objective it is decided to design the geometry of the gutter in the first stage so as to provide self cleaning velocity even at low discharges. Then the structural design of gutter will be taken up in the second stage. Finally its cost of construction will be taken up.*

***Key Words***: Gutter;Velocity;Discharge

## 1.INTRODUCTION

The waste products of a society had been collected, carried and disposed of manually to a safe point of disposal. This primitive method of collecting and disposing of the society's waste has now been modernised and replaced by a system, in which these wastes are mixed with sufficient quantity of water and carried through closed conduits under the conditions of gravity flow. This mixture of water and waste products, popularly known as sewage and the system is known as sewerage system. These sewage effluents may be disposed of after giving it suitable treatments, thus avoiding effluents may be disposed of either in a running body of water, such as a stream, or may be used for irrigation crops. The main objective of the present work is to design a self-cleaning gutter.

## 2. LITERATURE REVIEW

Ali R. Vatankhah1(2013) Side weirs are flow-diversion devices that are widely used in irrigation and drainage systems and combined sewer systems. Side weirs are also used as an emergency structure. They are important parts of distribution channels of irrigation systems. Computation of water Surface profile over side weirs is essential to determine the flow rate of the side weir. Analytical and semi analytical solutions for calculating water surface Profiles along a rectangular side weir in a U-shaped main channel were presented.

Mohammed Nadeem (2012) These paper present results of experimental investigations carried out to evaluate effects of replacing aggregate (coarse and fine) with that of slag on various concrete properties. The basic objective of this study was to identify alternative source of good quality aggregates which is depleting very fast due to the fast pace of construction activities in India. Use of slag - a waste industrial by product of iron and steel production provides great opportunity to utilize it as an alternative to normally available aggregates (course and fine). In this study, concrete of M20, M30 and M40 grades were considered for a W/C ratio of 0.55, 0.45 and 0.40 respectively for the replacements of 0, 30, 50, 70 and 100% of aggregates (Coarse and Fine) by slag. Whole study was done in two phases, i.e. replacement of normal crushed coarse aggregate with crystallized slag and replacement of natural fine aggregate with granular slag. The investigation revealed improvement in compressive strength, split tensile and flexure strength over control mixes by 4 to 8 %. The replacement of 100 % slag aggregate (coarse) increased concrete density by about 5 to 7 % compared to control mix. Based on the overall observations, it could be recommended that slag could be effectively utilized as coarse and fine aggregates in all the concrete applications.

By studying the literature as mentioned above it is found that the drainage concept, using curb-gutter-sewer systems, has led to downstream flooding, erosion, water-quality degradation, reduced groundwater recharge and stream base flow, and aquatic habitat destruction. The design criteria for sediment transport in sewers are the basis to avoid the risk of waste water sediments. The water surface profiles in rectangular and circular sections have been explained in which egg shaped section can be preferred to increase self cleaning velocity with in the gutter.

## 3.GEOMETRY OF GUTTERS

Channel is a section used for conveyance of water from one place to another place. There are two types of channels.Natural channels & Artificial channels.

**Fig -1**: Natural Channel

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**Fig -2**: Circular Gutter Channel

## 3.1. Water Carriage System

In this system, the excremental matters are mixed up in the large quantity of water and are taken out from the city through properly designed gutter systems where they are disposed off after necessary treatment in a satisfactory manner. The sewage so formed in water carriage system consists of 99.9 percentage of water and 0.1 percentages of solid matters. All the solid matters remain in suspension in the sewage and do not change the specific gravity of water. So all the hydraulic formulae can be directly used in the design of gutter system.

## 3.2. Types of Gutter Systems

The gutter systems are classifieds are as follows

a. Combined system
b. Separate system
c. Partially Separate system

- Combined system: There is no need of flushing because self-cleaning velocity is available at every place due to more quantity of sewage.The sewage can be treated easily and economically because rainwater dilutes the sewage.House plumbing can be done easily only one set of pipes will be required.
- Separate system: The domestic and industrial sewage are taken in one set of gutters, where as storm and surface water are taken in another set of gutters, it is called separate system.
- Partially separate system: In the separate system, if a portion of storm water is allowed to enter in the gutters carrying sewage and the remaining storm water flows in separate set of gutters.

**Table -1:** Geometric Elements of Channel Sections

| SECTION | AREA, $A$ | WETTED PERIMETER, $P$ | HYDRAULIC RADIUS, $R$ | TOP WIDTH, $T$ | HYDRAULIC DEPTH, $D$ | SECTION FACTOR, $Z$ |
|---|---|---|---|---|---|---|
| Rectangle | $by$ | $b+2y$ | $\frac{by}{b+2y}$ | $b$ | $y$ | $by^{1.5}$ |
| Trapezoid | $(b+zy)y$ | $b+2y\sqrt{1+z^2}$ | $\frac{(b+zy)y}{b+2y\sqrt{1+z^2}}$ | $b+2zy$ | $\frac{(b+zy)y}{b+2zy}$ | $\frac{[(b+zy)y]^{1.5}}{\sqrt{b+2zy}}$ |
| Triangle | $zy^2$ | $2y\sqrt{1+z^2}$ | $\frac{zy}{2\sqrt{1+z^2}}$ | $2zy$ | $\frac{y}{2}$ | $\frac{\sqrt{2}}{2}zy^{2.5}$ |
| Circle | $\frac{1}{8}(\theta-\sin\theta)d_0^2$ | $\frac{1}{2}\theta d_0$ | $\frac{1}{4}\left(1-\frac{\sin\theta}{\theta}\right)d_0$ | $(\sin\frac{1}{2}\theta)d_0$ or $2\sqrt{y(d_0-y)}$ | $\frac{1}{8}\left(\frac{\theta-\sin\theta}{\sin\frac{1}{2}\theta}\right)d_0$ | $\frac{\sqrt{2}}{32}\frac{(\theta-\sin\theta)^{1.5}}{(\sin\frac{1}{2}\theta)^{0.5}}$ |
| Parabola | $\frac{2}{3}Ty$ | $T+\frac{8}{3}\frac{y^2}{T}$ * | $\frac{2T^2y}{3T^2+8y^2}$ * | $\frac{3}{2}\frac{A}{y}$ | $\frac{2y}{3}$ | $\frac{2}{9}\sqrt{6}\,Ty^{1.5}$ |

# 4. DESIGN OF GUTTER

## 4.1. Design Considerations and Calculations

The water supply pipes carry pure water without containing any kind of solid particles, both organic and inorganic in nature. The sewage, on other hand, does contain such particles in suspension and the heavier of these particles may settle down at the bottom of the sewers, as and when the flow velocity reduces, thus results in clogging of the sewers. In order to avoid such problems, it is necessary that the sewer pipes be of such size and laid at such a gradient, as to generate self- cleaning velocities at different discharges. The sewer materials must be capable of resisting wear and tear caused due to abrasion of solid particles present in the sewage. The water supply pipes carry water under pressure, and hence, within certain limits, they may carry up and down the hills and the valleys. The sewer pipes carry sewage as gravity conduits, and they must be laid at a continuous gradient in the downward direction up to the outfall point, from where it will be lifted up, treated and disposed off.

Hydraulic formulas for determining flow velocities in sewers:

Using Manning's equation the velocity is determined, $V = (1/n)*R^{2/3}*S^{1/2}$

Where n = Manning's constant, R = Hydraulic mean depth,= area of the section / perimeter of the Section,S = Slope of the section

Capacity of the sewers: The capacity of the sewers is given by Q = A*V

Where A = area of the cross section of sewer
V = velocity of the flow

### 4.2. Design OF Shaped Sewer

Depth of channel D = 0.3m, Width of channel B = 0.3 m, Area of channel A = 0.068 sq.m

Perimeter of channel P =0.718 m,Hydraulic mean radius R = A/P = 0.095m

Using manning's formula of value of n as 0.015, Velocity of flow = 0.69 m/s

Capacity of the sewer Q = A*V = 0.068*0.69 = 0.05 $m^3/s$, The velocity in the above sewer is 0.69 m/s, which is more than 0.45 m/s, which is the numerical theoretical value of the self-cleaning velocity hence we can adopt this sewer in the field.

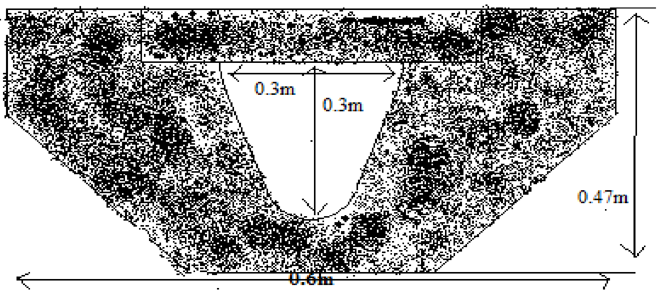


**Fig -3**: Design of Gutter

The design considerations of different types of geometrical sewer sections had shown. The slope, velocity and discharge of circular, rectangular, trapezoidal sewer sections have been determined. The calculation part done on excel sheet has shown. Finally the comparison of area, perimeter and top width of egg shaped sewers has been shown in graph.

## 5. FABRICATION OF GUTTER

### 5.1. Slump Cone Test

Slump test is the most commonly used method of measuring consistency of concrete which can be employed either in laboratory or at site work. It is not a suitable method for very wet or very dry concrete. It does not measure all factors contributing to workability, nor is it always representative of the playability of the concrete. However, it is used conveniently as a control test and gives an indication of the uniformity of concrete from batch to batch. Repeated batches of the same mix, brought to the same slump, will have the same water content and water cement ratio; provided the weight of aggregate, cement and admixtures are uniform and aggregate grading is within acceptable limits. Additional information on workability and quality of concrete can be obtained by observing the manner in which concrete slumps. Quality of concrete can also be further assessed by giving a few tapping's or blows by tamping road to the base plate. The deformation shows the characteristics of concrete with respect to tendency for segregation.


**Fig -4**: Slump Cone Test

Place the fresh concrete mix in the clean slump cone in three equal layers. Tamping each layer with 25 times by the tamping rod in a uniform manner over the cross section. Stricken of the top of the concrete flush with trowel i.e., exactly leveled. Remove the metal cone by raising it slowly and carefully in the vertical direction.As soon as the concrete settlement stop, measure the subsidence of the concrete. This subsidence is slump. In this present case the Slump value obtained = 11 cm

This is the most important test for workability of fresh concrete

- The dimensions of slump cone,Top diameter = 10cm,Bottom diameter = 20cm
- Height of slump cone = 30cm

### 5.2. Manufacturing of Cubes

Out of many test applied to the concrete, this is the utmost important which gives an idea about all the characteristics of concrete. By this single test one judge that whether Concreting has been done properly or not. For cube test two types of specimens either cubes of 15 cm X 15 cm X 15 cm or 10cm X 10 cm x 10 cm depending upon the size of aggregate are used. For most of the works cubical moulds of size 15 cm x 15cm x 15 cm are commonly used

**SPECIMEN:** 6 cubes of 15 cm size Mix. M30

- **HAND MIXING:** Mix the cement and fine aggregate on a water tight none-absorbent platform until the mixture is thoroughly blended and is of uniform colour Add the coarse aggregate and mix with cement and fine aggregate until the coarse aggregate is uniformly distributed throughout the batch Add water and mix it until the concrete appears to be homogeneous and of the desired consistency.

- **SAMPLING:** Clean the mounds and apply oil Fill the concrete in the moulds in layers approximately 5cm thick Compact each layer with not less than 35strokes per layer using a tamping rod (steel bar 16mm diameter and 60cm long, bullet pointed at lower end) Level the top surface and smoothen it with a trowel.
- **CURING:** The test specimens are stored in moist air for 24hours and after this period the specimens are marked and removed from the mould and kept submerged in clear fresh water until taken out prior to test.

PROCEDURE: Remove the specimen from water after specified curing time and wipe out excess water from the surface.

a. Take the dimension of the specimen to the nearest 0.2m
b. Clean the bearing surface of the testing machine
c. Place the specimen in the machine in such a manner that the load shall be applied to the opposite sides of the cube cast.
d. Align the specimen centrally on the base plate of the machine.
e. Rotate the movable portion gently by hand so that it touches the top surface of the specimen.
f. Apply the load gradually without shock and continuously at the rate of 140kg/cm2/minute till the specimen fails
**g.** Record the maximum load and note any unusual features in the type of failure.

**Fig -5**: Compacting the cocncrete in to cube shape

### 5.3. Testing of cubes

Out of many test applied to the concrete, this is the utmost important which gives an idea about all the characteristics of concrete. By this single test one judge that whether Concreting has been done properly or not. For cube test two types of specimens either cubes of 15 cm X 15 cm X 15 cm or 10cm X 10 cm x 10 cm depending upon the size of aggregate are used. For most of the works cubical moulds of size 15 cm x 15cm x 15 cm are commonly used.This concrete is poured in the mould and tempered properly so as not to have any voids. After 24 hours these moulds are removed and test specimens are put in water for curing. The top surface of these specimens should be made even and smooth. This is done by putting cement paste and spreading smoothly on whole area of specimen.

**Fig -6**: Cube shape Specimens testing in Compressive testing machine

The compressive test values of the mix m30 we got

| | | |
|---|---|---|
| Day 3 | - | 440 KN/Sq.mt. |
| Day 7 | - | 550 KN/Sq.mt. |
| Day 14 | - | 690 KN/Sq.mt. |
| Day 21 | - | 820 KN/Sq.mt. |
| Day 28 | - | 1080 KN/Sq.m |

**Fig -7**: Mixing total material specimen Preparation

### 5.4. Preparation of cubes

**Fig -8**: Compacting the Mix

## 6. COST ESTIMATION

The actual cost of a work is known at the completion of the work. Account of all expenditure is maintained day-to-day during the execution of work in the account section and at the end of the completion of the work when the account is completed, the actual cost is known. The actual cost should not differ much from the estimated cost worked out at the beginning.[Long wall length out to out = centre to centre length +half breadth on one side + half breadth on the other side=centre to centre length +one breadth]

For short walls subtract from the centre length one breadth of wall, which gives the length in to in, and repeat the same process as from the long wall, subtracting one breadth in side of adding {Short wall length in to in =centre to centre – one breadth}Preparation of detailed estimate consists of working out the quantities of different items of work and then working out the cost I.e. the estimate is prepared in two stages

**Fig -9**: Final Fabricated Gutter

For estimating, the different parts of the culvert should be considered separately. First the two abutments with foundations up to the springing level and then the portions of haunch or spandrel above the springing level should be taken up, and then the parapet walls should be estimated. Arch masonry should be calculated separately. Finishing work of the surfaces is taken up lastly.

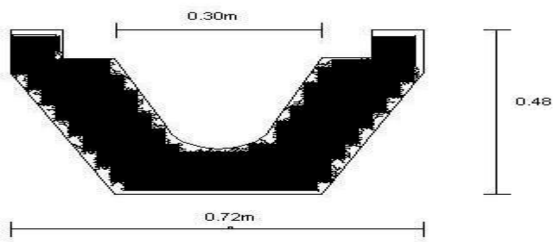


**Fig -10**: Dimensions of Gutter

### 6.1. Estimation of Rate Analysis

- Earth work excavation for 1cum = 120 Rs = 0.08388 * 120 = 11 Rs
- Cost of Cement concrete for 1 cum = 5000 Rs= 0.05988 * 5000= 300 Rs
- The overall cost of the prefabricated gutter = 311 Rs

## 7. CONCLUSION

In this project it is to propose the design and fabrication of gutter. Gutters have wide applications in case of field channels, convince of rain water and sullage. The present study involves the aspects such as, Design of gutter geometry and structural design, Fabrication of gutter in the laboratory, Cost estimation, Conclusions as per the work.

- Egg shape sewers are having good self-cleaning velocity compared with rectangular and others. Where sediments settle down which is unhygienic
- Egg shape sewers are having self-cleaning velocity so, regular maintenance is not necessary.
- At the field construction, there will be no proper curing as in the laboratory fabrication.
- This is of uniform and good quantity, as fabrication in the laboratory.
- At the field construction, there will be no proper curing as in the laboratory fabrication.

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