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Analysis and Design of Bridge Columns Supported on Monopiles

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Abstract: - Pile foundations are used to support heavy structures and can have a dual purpose of transmitting compressive force to deeper, heavier layers while also strengthening the soil. Piles are subjected to lateral loads in the foundations of bridges, transmission towers, offshore structures, and other structures built. This lateral load resistance of pile foundations is important in the design of structures susceptible to earthquakes, soil movement, waves, and other environmental disasters. The analysis is a technique for determining the ways of a structure under various loads. The process of establishing a convenient description for a structure is known as design. Manually planning and analysing a structure can take a long time. The analysis and design of any structure can be done easily with the use of software. This project aims to analyze and design of bridge columns supported on monopiles. viz., monopile and group pile. In this paper the study of literature reviews. Then to calculate the different types of design parameter load use IRC: 78-2014 and IRC 112-2011. SAFE 2016 stands for modeling structural analysis and design software. IS 456-2010 and IS 2911:2010 and also other Code is used for design and analysis. M35 grade of concrete and Fe-500 steel were used. In this paper a comparative analysis of monopile and Group pile is done for taking the load of bridge column. The results are presented in form of graphs viz., soil pressure, shear force, bending moment and permissible settlement.

***Index Terms*— Monopile, Group pile, SAFE 2016, soil pressure, bending moment, shear force, and permissible settlement.**

I. INTRODUCTION

A structure's foundation is the part of the structure that transfers the load to the soil on which it rests. It is an important factor of the structure. The base of the foundation is the ground surface that is in interface with the lower surface of the foundation. The sub-grade or foundation soil is the ground on which the foundation is structured. A foundation should be structured to safely transmit the structure's load to a sufficient area of the soil, keeping the stresses induced in the soil to a safe level. When a soil is overstressed, it can experience shear failure, which causes the soil to slide along a rupture plane and collapse the building. Another consideration is the necessity to achieve uniform settlements that are within the superstructure's tolerance limitations.

The soil underneath the structure is compacted due to the structure's load. The settlement of the soil depends on various factors like intensity of the loading, the quality of the soil and the depth below the surface level. To prevent massive secondary pressures, it is critical that the settlement of diverse components of a structure be the same. To obtain perfect settling, the foundation area must be designed in such a way that the degree of soil reaction under all of the structure's footings is the same. The foundation of a structure should be built to prevent the structure from tilting. If the foundation area of a structure is such that the centre of gravity of the loads does not coincide with the centre of gravity of the foundation area the consequent bearing reaction will be non-uniform. The pressure intensity will be higher at the edge closer to the centre of gravity of the loads, resulting in more soil settlement.

Foundations can be categorized into two types: shallow foundations and deep foundations. The difference in level between the ground surface and the foundation's base is referred to as the depth of the foundation. A foundation is described as deep if its depth exceeds its width. A pier is a cylindrical of body concrete which transfers the loads to the soil at a depth greater than its width. A pile is a long, narrow member that transfers force to the surrounding soil by friction or through its lower end into a strong stratum.

II. METHODOLOGY AND BRIDGE DESCRIPTION

In this research paper, the monopile foundation structure has been modeled and designed for loadings such as dead load, live load, superimposed dead load, braking force, water current force, seismic, wind and lateral loading. Then, to be calculating ultimate load carrying capacity of monopile foundation in soil as per IRC 78-2014 and IRC 112-2011 and also other IS CODE. After the calculation of the ultimate load carrying capacity is safe for design and Analysis. The design and analysis of monopile pile foundation of manual calculation by using SAFE 2016 Software. In this paper the compilation of monopile and group pile foundation result are shown in graphs.

A. Basic Design Data

<u>LEVELS</u>

1. Formation Level FRL = 48.007 m
2. Bearing Level BRL = 46.562 m
3. Pile Cap Top Level FTL = 44.000 m
4. Pile Cap Bottom Level FBL = 42.200 m
5. Earth below ground Level = 0.42 m
6. Clear Height of Pier = 2.0 m
7. Depth of Pile Cap =1.8m

B. Soil Parameters

1. Angle of Repose of soil, ϕ (in degrees) ϕ= 30.0
2. Cohesion, C (in t/m^2) C= 0.0
3. Angel of wall friction δ= 20.0
4. Density of Soil (dry), γ_b (in t/m^3) γ_b = 1.80
5. Density of Soil (submerged), γ_{sub} (in t/m^3) γ_{sub} = 1.00
6. Coefficient of Friction at base between soil & concrete m = 0.05
7. Unit weight of concrete (in t/m3) γ_c = 2.5
8. The bearing capacity of the soil taken as Geotechnical report =250kN/m^2

C. Details

Table No. 01

D. *Soil Subgrade*

1. Taking the SBC of Soil as 250 kN/m^2
2. Assuming Maximum Settlement in Pile As 50 mm
3. Subgrade modulus =15000kN/m^3

PILE DETAILS		SOIL DETAILS	
Parameter	Circle cross-section	Parameter	Values
Diameter of Pile	1200mm	Angle of internal friction (ϕ)	30^0
Length	20m	Submerged density γ_{sub}	10 kN/m^3
Type of pile	Concrete	Unit weight (γ)	18kN/m^3
Grade of Concrete	M35	Backslope angle (α)	90

E. *Design Parameter*

<u>LOADING</u>

1. Dead Load (DL) = 25KN/m^3
2. Super Imposed Dead Load (SIDL) = 22kN/m^3.
3. Live Load (LL) = Live Load conforming to As per Table 2 IRC: 6 – 2014 have been considered in the analysis of the structure.

The LL has been considering Class of Loading 3 Lane.

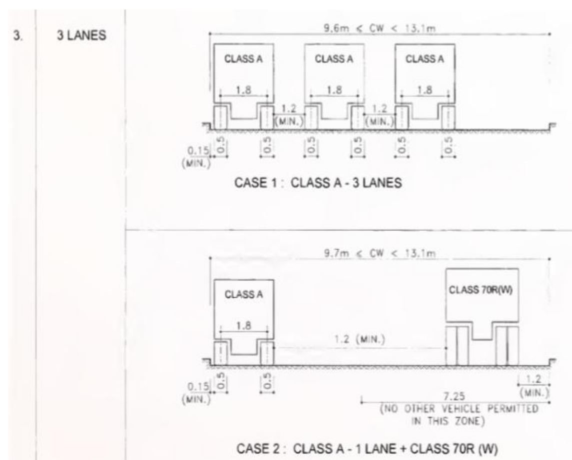


Fig: 1.Lanes

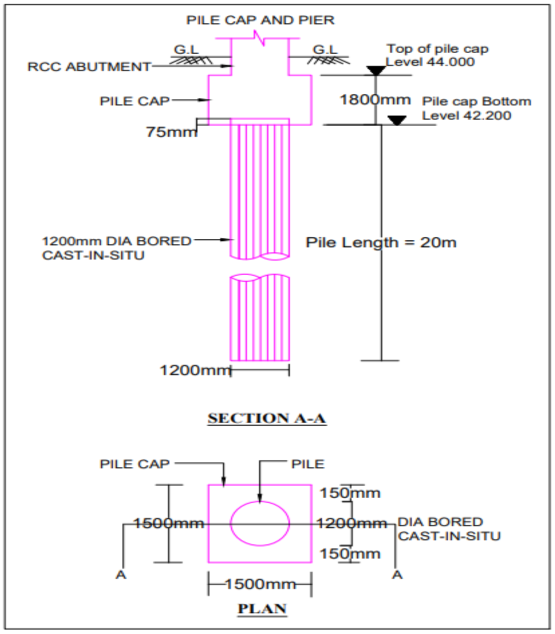
4. Braking Force

The Braking Force has been calculated for 20% of total carriageway live load at that designed Section. As per IRC: 6 – 2014.

5. Seismic Force

Seismic Zone-II Seismic forces are also considered in the design having with zone factor of 0.1 as per IRC: 6.

III. MODELLING OF MONOPILE AND GROUP PILE



MODEL

The Modeling of Piles is done on SAFE 2016 Software

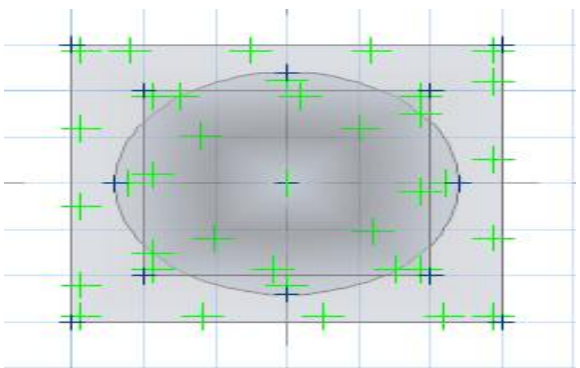


Fig: 2. Monopile

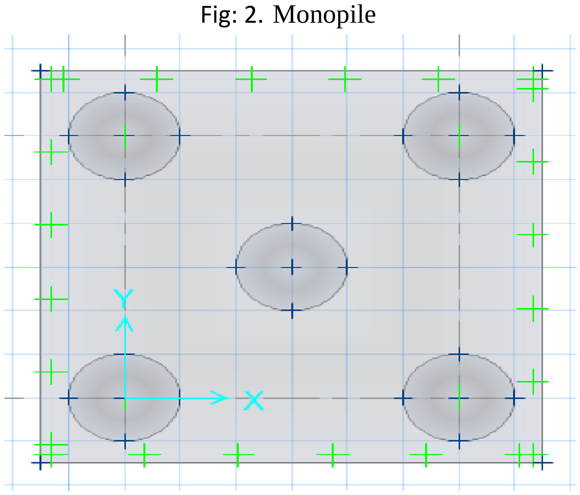


Fig: 3. Group Pile

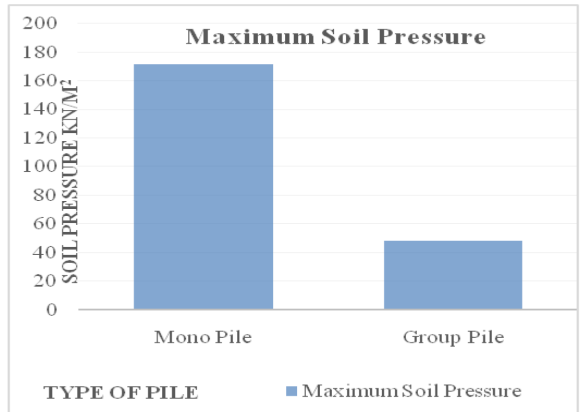
IV. RESULTS AND DISSCUSION

Taking Pile Diameter =1200 mm
Factored Load = 6000 kN = 600 ton
Concrete Mix = M35
Steel Grade = Fe 500

1. Maximum Soil Pressure

Maximum Soil Pressure	
Type	Soil Pressure kN/m^2
Mono Pile	171.6
Group Pile	48.024

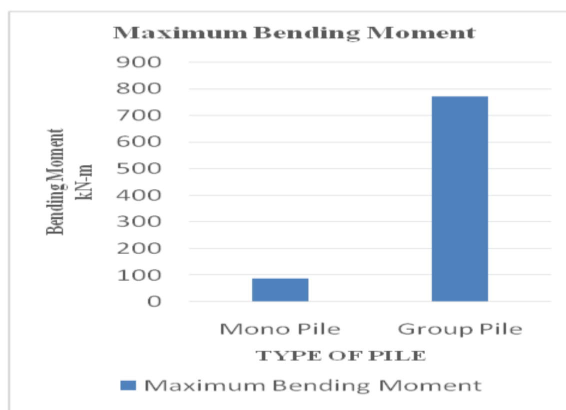
Table No. 02



2. Maximum Bending Moment

Maximum Bending Moment	
Type	Bending Moment kN-m
Mono Pile	88.8
Group Pile	770

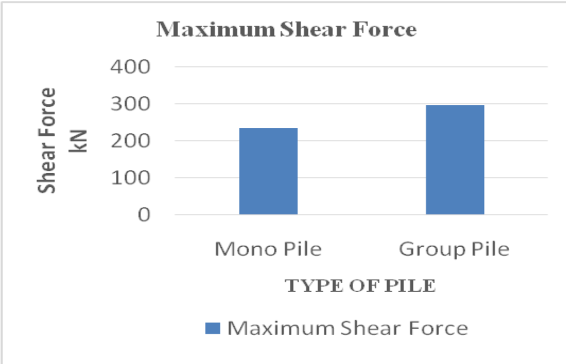
Table No. 03



3. Maximum Shear Force

Maximum Shear Force	
Type	Shear Force kN
Mono Pile	234
Group Pile	296.4

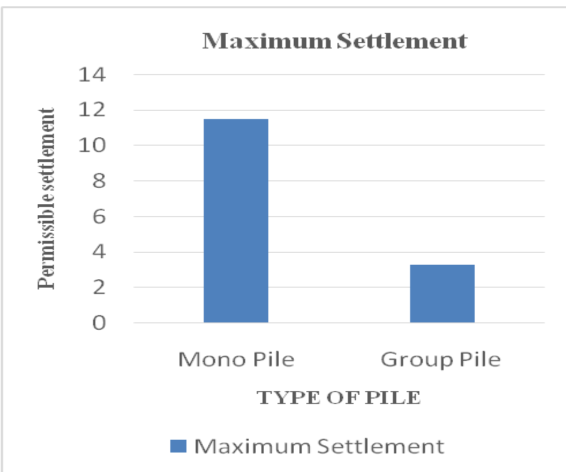
Table No. 04



4. Maximum Settlement

Maximum Settlement	
Type	Settlement (mm)
Mono Pile	11.46
Group Pile	3.264

Table No. 05



- The Modeling and Analysis is Done on SAFE 2016 Software.
- The Comparative results taken to be as

1. Maximum Soil Pressure
2. Maximum Bending Moment
3. Maximum Shear Force
4. Maximum Settlement

V. CONCLUSION

- The Mono-pile Foundation having Soil Pressure which is 171.6 kN/m^2 and it is below the SBC of Soil which is 250kN/m^2 so the Monopile is safe under Soil Pressure Condition.
- The Bending Moment of the mono-Pile Cap is less as the pile cap is small as compared to Group Pile.
- The shear force of the mono-pile Cap was also found to be less as the pile cap is small as compared to Group pile.
- The Settlement of monopile was found to be 11.46 mm which is well within permissible settlement of pile.
- A Monopile of Size 1.2 m diameter is suitable for Construction when the overall load is under 6000kN.

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