DESIGN AND CONSTRUCTION OF BOUNDARY PROTECTION SYSTEM ON THE EAST AND SOUTH BOUNDARIES OF RVCE CAMPUS ALONG THE VRISHABHAVATI RIVER, BANGALORE, INDIA

Pajar K. L. * and Iyengar S. N.
United Foundations Pvt. Ltd., R. T. Nagar, Bangalore (INDIA)

Received June 05, 2015
Accepted October 10, 2015

ABSTRACT

The campus of RVCE (the premier engineering institute) in outskirts of Bangalore has the River Vrishabhavathi as its boundary on South and Eastern sides. During the rainy season, the river level goes up and inundates the campus and creates problems for inmates of the hostel situated on its banks. With the industrial development in the vicinity of the river and the discharge of waste water, the river water is highly contaminated and is posing health and allied problems for the inmates of the campus. A compound wall built all along the boundary on river bank, collapsed due to the force of flood water and a lasting solution was needed. To study and suggest the lasting solution to the problem, RVCE authorities contacted United Foundations Pvt. Ltd. to study the ground realities and suggest a system which would sustain the fury of floods and help improve the utility of the area along the river course. On careful study of the ground realities and geophysical condition of the site, the team from United Foundations Pvt. Ltd. suggested a system of contiguous piles driven all along the boundary which would act as a permanent retaining wall and dissipate the energy of the flood water with the semicircular shape of piles placed in the row creating corrugated front acting as energy dissipaters. At places where the anchor depth in the bed is not sufficient, shear pins are used to provide required anchors for the piles. With the capping beam on the top of piles acting as the tie and also as the means to hold back the piles with the system of anchor beams placed at intervals. By providing a cantilevered slab overhang on river side of the pile to the extent of original boundary now in river course due to scouring, the area on the campus side can be utilized for a peripheral road and provide a river front as well. It is particularly interesting to mention here that during construction period itself, the part of the new system experienced the fury of flood and has withstood the same successfully.

Key Words: Shear pin, Contiguous piles, Anchored footings, Contamination, Dissipater

INTRODUCTION

Fig. 1 shows an aerial view of the location of R.V. College of Engineering, Mysore Road, Bangalore, India and the Vrishabhavathi river flowing along the part of East and South boundaries of the college area. The river meanders along the boundary causing many curves along the path of flow. During rainy season (April to August and October and November), the river flows full. At the curved portion due to deposition of earth on the outer side and scouring of the bank on inner side the boundary line has shifted in to the river course considerably, resulting in loss of useful area of the campus.1,2 Some student hostels, canteens and play grounds are situated very close to the Southern boundary of the college campus.2,3 Water flowing in the river being highly contaminated due to discharge of waste on the upstream side. Whenever, the river flows on high floods during rainy season, the whole area turns out to be unhealthy and approach to Southern boundary of college campus becomes extremely difficult, almost impossible.

*Author for correspondence
A size stone masonry wall was built some time back all along the river bank to prevent the water entering the campus. This wall got damaged during high floods in the river in recent days. This has necessitated design and construction of a permanent system that would act as an effective barrier that would prevent scouring of the banks and entry of river water in to campus especially in high floods. This permanent system should not have any effect on the flood intensity.

**DISCUSSION**

**Field observation**

The following points were observed during site inspection:

i) River bed is rocky with bed rock and large size boulders at several places along the course.

ii) Flow has high velocity even in normal days.

iii) Water in the river is highly contaminated and may be acidic in nature.

iv) The construction on the opposite bank is reducing the width of river course causing increase in velocity and raise the high flood level.

v) River course has many sharp bends.

vi) Recorded MFL is RL 102.17m, present road level is RL 99.72m and water level during starting of work was RL 97.17m. Average depth of water over river bed during high flood season is about 4m to 5m and will come down to 2m to 3m during normal days.

**Proposed boundary protection system**

The system that is to be devised should resist the water force of the river flow, prevent erosion both at founding level and the banks, resist lateral pressure and overturning effect. Considering the above requirements of protection system, following systems were studied:

a) Reinforced RR masonry wall with RCC foundation anchored in rock (bed rock)

b) Rock anchored RCC foundation with RCC columns and suitable frame work of RCC/RR masonry wall

c) Diaphragm wall / sheet pile wall

d) Installation of touch pile wall (contiguous pile wall)

Suitability of each system was studied keeping in view the following factors:

a) Economy

b) Practical applicability

c) Speed of execution

Length of boundary along the river front is of the order of 700 to 800 Rm. For such a long stretch with varying soil conditions, two
systems out of four mentioned above were
found to be suitable. These system fulfill all
the factors mentioned above:
1) A barrier of contiguous pile wall, capping
beam, slabs and parapet wall as shown in
Table 1. This system is suitable where depth of
soil is 4m and above, followed by bed rock
layer
2) Rock anchored RCC footing of suitable
size constructed at 3m c/c with RCC
columns and RR/RCC wall in between
columns. This is suitable where rock is on
the surface or at a shallow depth of about
2m to 3m below existing ground level.

Fig. 2 : Design of capping beam and slabs with parapet wall for RVCE compound wall work

System 1 : Construction of contiguous pile
wall, capping beam
These days, bored cast in situ piles are being
installed by using hydraulic rotary machines.
By using these machines, the work will be
speeded up. But the ground conditions in the
present site are not suitable for using such
heavy machinery. Piles are being installed at
the edge of the river bank where soil is very
soft and due to floods in the river the soil has
been eroded many times. Fig. 3(a) and Fig.
3(b) show the site condition after such floods.
This condition would have definitely
destabilised the machine leading to accidents,
damage and loss of machine. Hence, in this
situation, the tripod system of piling has been
used. In this case, two out of three legs of the
tripod are firmly fixed on the bank of the river
and the machine (weighing about 2MT) and
main leg of the tripod are on the firm ground
some distance away from the bank of the river.
After fixing the tripod on the centre of the pile
point, the boring operation starts by using
bailer and chisel. Top temporary casing of
about 4m long is fixed to prevent the collapse
top soil. Boring is done up to minimum of
50cm penetration into base rock. Prefabricated
steel reinforcement cage is lowered along with
MS pipe of 200mm dia for full length of pile.
Concreting is done by using tremie method.

Fig. 3(a) : Site condition after flood on 7th June, 2014
Fig. 3(b) : Site condition after flood on 18th July, 2014

Since these piles are designed as lateral piles, the main function of these piles is to withstand the lateral pressure of soil and water from land side and from river side. For this purpose, the piles must be anchored into rock for a depth of 2m as per the analysis. Work is being done on the bank of the river without disturbing the green belt area.

Analysis has been done by using Finite Element Method and Plaxis software is used for this. Results are presented in Fig. 4(a) to Fig. 4(c). Anchorage of 2m is achieved by providing shear pin at the bottom of the pile.

Fig. 4(a) : Horizontal displacement of 10mm

Fig. 4(b) : Bending moment -65.3kNm/m
This system of providing shear pin is achieved by drilling bed rock through 200mm MS pipe, that is provided in the RCC pile before casting, for a depth of 2m below the termination depth of pile and inserting 100mm ISMB 4 meter in length with 2m anchored in drilled hole in bed rock and 2m within pile portion. Then the ISMB and MS pipe are grouted with M20 concrete using 12mm stone aggregate. This system will ensure the anchorage of pile for 2m depth in the bed rock.

Capping beam is cast on top of pile wall which connects all the piles. From this capping beam, cantilever slab is taken out for 2m length, i.e. up to the boundary of the college campus. This system is shown in Fig. 2. For providing contiguous pile wall, the requirement is that the location should have minimum of 4m soil over rock strata.

The compound wall does not have any effect on the flood intensity, while the entry of flood water into the campus will be prevented thus keeping the peripheral road and ground free from contaminated water and wastes dumped into the river and avoiding environmental hazard.

**System 2: Construction of rock anchored footings and wall**

In some locations along the river bank, the bed rock is seen on the ground surface or bed rock is available at about 2 to 3 m depth from ground level. In such cases, the open foundation is designed and is anchored into the rock by drilling holes of 50mm dia for 2m depth inside the rock, inserting a 32mm dia steel rod for full depth of the hole and minimum of 80cm anchorage length of rod in the RCC footing. All such footings are connected by grade beam at varying depths. This system is checked for resisting the sliding forces of water and soil during high flood levels. RR masonry wall or RCC wall is constructed on the grade beams. Fig. 5 shows the open foundation system.
CONCLUSION
Contiguous pile wall system is well suited for this situation. Similar system is provided by us on the upstream of the Vrishabhavati river for a factory building and this system is working very efficiently. This system is economical and safe. Overflow of contaminated river water into the college campus is prevented. Width of river is not affected with this system. Bio diversity of the river is not affected by the work being carried out. However green belt area, soil and other environmental parameters on the river were not examined.

ACKNOWLEDGEMENT
We are thankful to the Principal Dr Satyanarayana B. S., Vice Principal, Dr. Subramanya K. N., Advisor Prof. Raja Rao K. N. and Dean Infrastructure, Prof. Shivakumar B. L. of R.V. College of Engineering, Bangalore, India for their support and assistance in providing technical information about the project, thus enabling us to provide the design and analysis and carry out the work.

REFERENCES

Environment should be put in the category of our national security. Defense of our resources is just as important as defense abroad. Otherwise what will remain there to defend?

Robert Redford