The Lagos Journal of Environmental Studies
Vol. 1, 24-36

CREATIVE LANDSCAPE DESIGN OVERCOMES EROSION AND MUDSLIDE AT A RESIDENTIAL HOME ON (OPEBI) STEEP SLOPE

Jerry N. Obiefuna
Dept. of Architecture, University of Lagos, Akoka, Lagos

Abstract

A sloping site can offer creative design possibilities for a building and its landscape if the slope formed a major consideration in evolving a design for that site. Conversely, it can produce unanticipated problems such as unusually 'tall' building, erosion and mudslide, if such requisite considerations are not brought to bear on design decisions. The converse was the case with a partly terraced one-storey residential building located on a sloping 0.15ha plot on the steep Opebi slope, Ikeja, Lagos. The roofing of this residence accelerated gully erosion and mudslide severely threatening its foundations on the side abutting the slope. Prior solutions by the owner and the designer of the building centered on slope stabilization with laterite filling and compaction with heavy equipment. This would have involved over 6,400m^3 of laterite at a cost of over ₦300,000.00 (three hundred thousand Naira) in 1991. In consonance with the client's wish for a creative and less expensive landscape design solution, a comprehensive site analysis and design synthesis yielded a solution which incorporated terracing, retaining walls, surface and subsurface drainage, slope stabilization with planting and general landscaping measures. All these were geared towards efficient, rapid collection and disposal of roof and surface runoff thereby minimizing its erosive power, creation of lawn areas as delay areas for runoff as well as fulfilling the aesthetic and functional needs of the household namely: beauty, safety, play, clean air and environment among others. This paper discusses all the challenges and processes which culminated in the successful design and implementation of this project as a reference for similar sites with steep slopes. Furthermore, some salient observations on client relationship in residential site design are highlighted.

Keywords: Landscape, creative design, steep slope, terracing.

Introduction

Background

A sloping site can offer creative and interesting design possibilities for a building and its landscape if the slope formed active consideration in evolving a design for that site. The building floors can be split with the slope to achieve sub floors, while the landscape can be terraced in compliment to create different gardens or use areas for public and private access. Ideally, this should be if the professionals responsible for evolving both the building and landscape design were brought together in a creative symbiosis during the design and setting out stages.

But in a newly developed residential home on Opebi gorge, Ikeja, while the slope affected the building floor, the impact of this massive house on the adjoining slope manifested clearly when construction was at an advanced stage. In creating a grandiose entry, the building was sited too far back into the gorge. Over-site erosion, which hitherto was prevalent, became exacerbated with the roofing of the house. Downspouts from the roof gutter accelerated gully The dilemma which confronted the owner at this juncture was that he never retained the services of the architect who designed the building for the necessary supervision of construction. Instead, he relied solely on his contractor and do-it-yourself solutions which both of them generated. One of such initiative led to the construction of a 450mm thick and 2.4m high retaining wall midway down the slope into the gorge and sub-sequentially pilling 2.0m laterite filling against it with aim of achieving a level surface. Needless to say, the next rain precipitated the eloquent collapse of this monstrous and costly wall into the gorge and the frightening resurgence of the threat to the building foundation.

It was against this background that the input of a landscape designer towards a quick and less expensive solution was solicited.

The Brief

Following preliminary discussions, the client offered a brief which tended to mask his apprehension as it was merely described as 'a Landscape design of the entire site to consist of the following: provision of drainage, slope stabilization, fence wall, driveway and parking, security post, 4 carports, generator house, gardens and supervision of execution'. However, this brief was interpreted to mean demand for these actions namely: Stop erosion and its threat to the building foundation, save the house at a very reasonable cost; make the house and compound usable and safe;

erosion and subsequently threatened the building foundation at the back or the lower end of the building.

beautify the home landscape and provide for ancillary needs of the household.

This brief was given in early March 1991. The obvious handicap with this timing was that design proposals had to be evolved quickly and simultaneously with their implementation. The onset of rainy season and a few more washouts would have been catastrophic for the building.

Methods

The Site

The site is a 0.15ha residential plot located at Opebi Gorge in Opebi G.R.A., Ikeja, Lagos. Generally, it slopes backward from the access road at the average rate of 10% (10:1), achieving over 12% or 8:1 slope at the back of the building. From the crest of the gorge, it slopes steeply at about 50% or 2:1 into the Opebi valley and marsh 8 meters below.

The building itself, with a volume of about 3500mm^3 is partly terraced with living areas on the ground floor; sleeping/family quarters upstairs while the boys quarter and office space were accommodated in the basement level at the back. Its architecture is principally of the international style with an unpretentiously grandiose entry façade. A flight of stairs link the kitchen on the ground floor level with the basement.

Site Analysis

Initial site reconnaissance in conjunction with a structural engineer revealed that the building was sited too close to the crest of the gorge. Erosion was thus most severe at those ends of the building adjoining this gorge; that is, the boys quarter and office areas. Infact, at the corner between these two areas, only a thin layer of soil remained to expose the foundation footing of the building. Also, half of the retaining wall constructed at the crest of the gorge to safeguard these two areas had sheared off due to the burden imposed by over 2.0m laterite filling. Furthermore, a massive interceptor precast concrete channel was emplaced near the crest of the gorge to intercept all runoff from the frontage and right side of the building. The steep slopes of the gorge were covered with overgrown brush thereby making difficult a clear assessment of the magnitude of the problem below. Based on this initial assessment and because the client was visibly under pressure to take action rapidly, a suggestion was put forward to investigate the possibility of a short retaining wall at the bottom of the slope. The aim of this was twofold: to check soil creep and mudslide downslope and to reduce the extent of overall filling by achieving slopes of 3:1 or greater. Geotechnical investigation was therefore necessary to determine the feasibility of this suggestion. The spontaneous rejection of this idea and the clients expressed unwillingness not to engage as he put it 'in another high sounding and expensive investigations' prodded our curiosity. This led to more incisive questioning and more detailed site analysis. Consequently, access was gained with reasonable difficulty to the gorge and marsh below. From this viewpoint up, the actual magnitude of the problems and attempted solutions were manifested and carefully documented. A memo and report in late March 1991 detailed these findings. In the report, a comprehensive review of all solutions previously suggested and/or attempted was made and possible course of actions indicated as follows:

a). Retaining Wall: The extent of the previously attempted concrete retaining wall and filling was more widespread and massive than originally presented. The wall had a minimum measurement of 0.45 x 2.4 x 46m. Its collapse coupled with the enormous cost accounted for the client's apprehension towards another retaining wall. Of course, the wall was confirmed to be self-innovation as no architect or engineer was retained contrary to the client's claim.

b). Slope Stabilization by Filling and Compaction: This as was suggested by professionals hitherto invited would consume over 6,400m^3 of laterite at a cost of over N300,000.00 at the time. Achieving an embankment of 3:1 slope orbetter implied reclaiming a sizeable portion of the marsh below, which really did not belong to the client. Moreover being a catchment area, the ecology of the gorge stood to be adversely effected.

c). Short Retaining Wall/Filling and Compaction:

This combines (b) above with a short, fully buttressed retaining wall at the property line near the bottom of the slope. The aim was to avoid incursion into the marsh and reduce the quantity of filling.

d). The obvious drawback to (b) and (c) above was that maneuverability of heavy equipment within the tight space in the compound would be cumbersome if not impossible. In addition, the steep grade would render utilization of even hand-operated compactor extremely difficult.

e). With the above shortcomings, the problems were disaggregated to create possibility, for individual solutions to each to coalesce into a creative but less expensive comprehensive solution. The problems basically were: erosion and exposure of foundation footing of the house at the back; the sources of erosion were over site runoff and roof runoff; roof runoff was most destructive as down spouts from roof gutter splash on the foundation and runoff roams freely downhill; pronounced soil creep and mudslide downslope and lastly general landscape design and environmental restoration to soften architecture and humanize the entire home environment.

The measures imperative to combat above problems were identified as: rapid, efficient collection and harmless disposal of runoff, both over site and roof at the valley bottom; the reduction of the erosive power of runoff by a combination of interception, slope reduction, terracing and slope stabilization; the creation of lawn areas to reduce runoff quantity and use of quick growing groundcover or grass to stabilize slope; general landscape design which incorporates all solutions into a scheme that caters for the aesthetic and functional needs of the household including safety, play, clean air and pleasing environment among others.

Synthesis: The synthesis of all the foregoing led to the decision that the relatively inexpensive solution lay in the combination of terracing, retaining walls, surface runoff interception and subsurface drainage, slope stabilization and planting. The crucial factor in this was the location and treatment of retaining walls so as to be free standing and not burdened by laterite fill.

Design Proposals

Extensive site demonstrations and explanations were necessary to convince the client on the efficacy and cost effectiveness of the solutions before approval to proceed was given. As already indicated, the onset of rainy season meant that implementation had to proceed apace with design.

The Site Plan

The style of the building dictated the site plan form. The plan form conforms to the rectilinear form of the building with intervening curves dictated by both aesthetic demands and need for efficient vehicular circulation. (Fig.1). Having sited the four garages and generator shed on the right boundary of the site, the entry gate was located to take advantage of the vista into the gorge and neighboring Oregun area. Also, this location provided a pictorial view of the entry arcade of the building.

The main rear retaining wall was sited on the crest of the gorge which was just 1.0m outside the interceptor channel to trace the attitude of the crest through the office to the boys' quarter where it linked the existing half broken wall. For security, this wall was later extended to 3.5m height at client's behest to serve as perimeter fence. To demarcate the semi-public spaces (front lawn and parking) from the semi-private/private spaces behind (personal office and boys quarter), a doorway or small gate was incorporated after the interceptor channel. From this gate, a combination of landings and 12 stairs descends to the office space. From here another set of 5 stairs descends to the boys' quarter level (Fig. 2a).

To accommodate the slope, the floor of the garages was terraced. Similarly, the generator shack was terraced down from the garages (Fig 3). Altogether, this had the effect of making the structures less imposing and relate to human scale. Siting the garages to the right boundary also had the effect of creating ample vehicular circulation and parking space. The lawn area defined by the low retaining wall terracing the generator house provides a green backdrop to the concrete surfacing of the vehicular parking. Left of the entry foyer to the building was devoted mainly to lawn, garden and sand pit for children's play.

Boys' quarter/basement area

This area presented the most crucial challenge as it was the area of severest erosion, broken walls and huge laterite overburden. Being that overburden and hydraulic pressure were the main problems, the solution consisted of excavating the existing laterite filling by a minimum of 1.0m deep; restructuring of the retaining wall to be able to stand without upturning and provision of weep holes at regular intervals below the surface to reduce hydraulic pressure from seepage. Also, roof downspouts were to be connected directly to the drainage sump and outfall installed within this area. All these were achieved. This resulted in the B/Q being accessed by a flight of 7 stairs and a landing which were not in the initial building design (Fig. 2a). Also, the septic tank and soak away hitherto constructed here had to be broken and lowered to conform to the new levels.

Grading or levels

As already indicated, the resultant landscape plan consists of four main levels from the front to the rear yard. On the right, the driveway and parking consists of one level sloping backwards towards the gorge at 8%. The left side of the building maintains this slope towards the 3.6m retaining wall demarcating this space from the private space below. The right lawn in front of the generator house consist the second level. The semi-private space (office) consists of the third level being12 stairs down. The B/Q area is the 4th level being yet 5 steps down from the former (Fig. 2a & b).

Drainage

The commanding importance of effective drainage in a site of this nature cannot be overemphasized. The treatment of the drainage systems largely abided by the client's wish not to see open channels. Thus, the system was mostly subsurface comprising of 150mm PVC pressure pipes and channels. Channels used were covered with either concrete slabs or metal strips welded to angle bars. Catch basins were provided at the intersection of drainage lines especially those from the lawns and circulation areas to provide for cleaning of slit. Two drainage networks culminating in two large drop inlets (DI) in the rear cater for all overland and roof runoff from the site. Using the front entry foyer as a watershed, one network collects all runoff from the left side of the building conducting them to the DI and outfall near the boys' quarter (Fig. 4a, b). This inlet is also the receptacle for 60% of the roof runoff as well as runoff from the office area. The second network covers the right side and consists of a secondary channel and the main interceptor channel which feeds into the second large drop inlet located in the rear, adjacent to the generator house. The secondary channel receives all overland flow and roof drains from security post, garages and part of the main building and feeds to the main interceptor channel. The latter hitherto installed and very bulky was retained and re-configured to feed all effluent from this area to the DI (see Fig. 1).
A critical element in the drainage design was the harmless discharge of the effluent in the valley below. To this effect, the two rear drop inlets and outfalls were connected by 3-4 150mm PVC pipes to two concrete splash basins below in the toe of the gorge. These basins were rip-rapped to prevent erosion while the neck of the pipes was secured with insitu concrete collar to prevent slippage due to steep slope.

Slope stabilization

To ensure continued stability of the building foundation as well as the retaining walls, the steep slope into the gorge needed to be stabilized. This was achieved through three measures namely: reduction in the height and overall gradient of the slope; interceptor channel and terracing; top soiling and planting.
By allowing the retaining wall to trace the crest of the gorge, it was possible to sink this wall 2.5m deep from the upper level. This way, 1.5m of earth was excavated on the lower side thereby reducing the height of the slope. To prevent excavated material cascading entirely to the valley bottom, 600mm high board panels were staked across slope at 5m intervals. These were used to achieve terraces and also to spread topsoil over the slope. The boards were removed before planting to achieve liberal gradation between terraces. Also, it was necessary to stabilize the loose soil with hand held ramming device. As this was occurring in May, Kikuyu grass (Pennisetum clandestinum) was selected and used as the fastest and most aggressive ground cover to stabilize the slope in shortest possible time. Young dwarf coconut palms (Coscus nucifera) along with some economic trees with fibrous root system were also planted on the slope to provide long term stability.

Planting plan

The aim of the landscape planting was to soften the imposing architecture of the building and create human scale. Linear approach to planting was largely adopted especially with the shrubs (Fig. 5a-c). This was in deference to the client's desire for shrub-lined driveways and walkways. Few specimen trees such as Flamboyance, Pink cassia and Ashoka or Masquerade tree were informally planted to provide accents and shade as well as accentuate the imposing nature of the architecture. Port-Harcourt carpet grass (Axonopus compressus) and Kikuyu were used on the lawns to create different effects and utility. All plant beds and lawns were edged with kerbs.

Observations and Conclusion

As expenditures on materials and labour were shrouded in secrecy, the only way to show the cost effectiveness of the implemented solution is in terms of eventual quantity of laterite filling imported from outside the site and some other materials used. In all, a total of 30m^3 of laterite was brought in and used mainly to achieve levels. None was used on the steep slope apart from that obtained from excavation for the retaining wall. This is as opposed to over 6400m^3 prescribed in earlier solutions. Also, only 55m^3 of topsoil and 7m^3 of animal manure plus a bag of NPK fertilizer were employed. The total volume of concrete used for the concrete retaining walls was about 34m^3.The project spanned an entire year due mostly to hiccups associated with both funding and heavy rains from June -- September. Nevertheless, it is gratifying that out of sometimes very frustrating endeavor has emerged a home landscape devoid of washouts and mudslide. Most of all, there has emerged a cherished home landscape fulfilling the requisite functional and aesthetic needs of the household. A good maintenance regime which was emphasized and which has been adhered to by the household has enabled the intended forms and appearances to be realized in the two years following construction.

Finally, some observations made in the course of the project are relevant to similar cases elsewhere namely:

a). Requisite professionals should be brought together at the design stage and setting out to minimize consequent problems associated with building on a sloping site.

b). Residential landscape design, especially on a sloping site is not merely planting shrubs and a few specimen 'flowers'. Sensitive handling of level changes, functional demarcation of spaces, effective and aesthetically pleasing drainage coupled with detailing of site elements plus judicious planting are its constituent aspects.

c). Clients also can be more open-minded with information which will aid successful design solutions especially with past failed efforts if any.

d). In private projects of this nature, comparative cost statements can at best be a conjecture as the clients hardly disclose correct expenditures on materials and labour.

e). Clients also can be more responsive with information in post performance evaluation. This helps in assessing the continuing efficacy of design measures and systems.

Credits: The owner of the project, TIL, Ilupeju, Lagos is gratefully acknowledged for the opportunity to do this work. Also, associates on the project, U. Udoh (Arc.) and O. Dike (Structural Engineer) are acknowledged for their immense contribution to the implementation of the project.

References

Arup Associates (1991): Royal Life, Peterborough. *The Arup Journal. Autumn* 1991, 26 (3): 3 – 10.

Bonner, M. and Ferguson, D. (1992): Legal & General, Kingswood: Architecture in Lanadscape. *The Arup Journal.* Winter 1992–93, 24 (4): 3 - 9.

Obiefuna J. N. (1994). Human Spatial Behaviour as Basis for Outdoor Design in Nigeria. *Faculty of Environmental Sciences (University of Lagos) Special Publication Series* vol. 1: 11 - 23.

Weatherly N. E. ed. (1981). Planning Your Home Landscape. *Bulletin No. 673.* Co-operative Extension Service, University of Georgia, Athens, Georgia.

Weber, N. M. and Adams, M. (1982). *How to Plan Your Own Home Landscape.* The Bobbs-Merrril Co. Inc., New York. 286p.

Figures

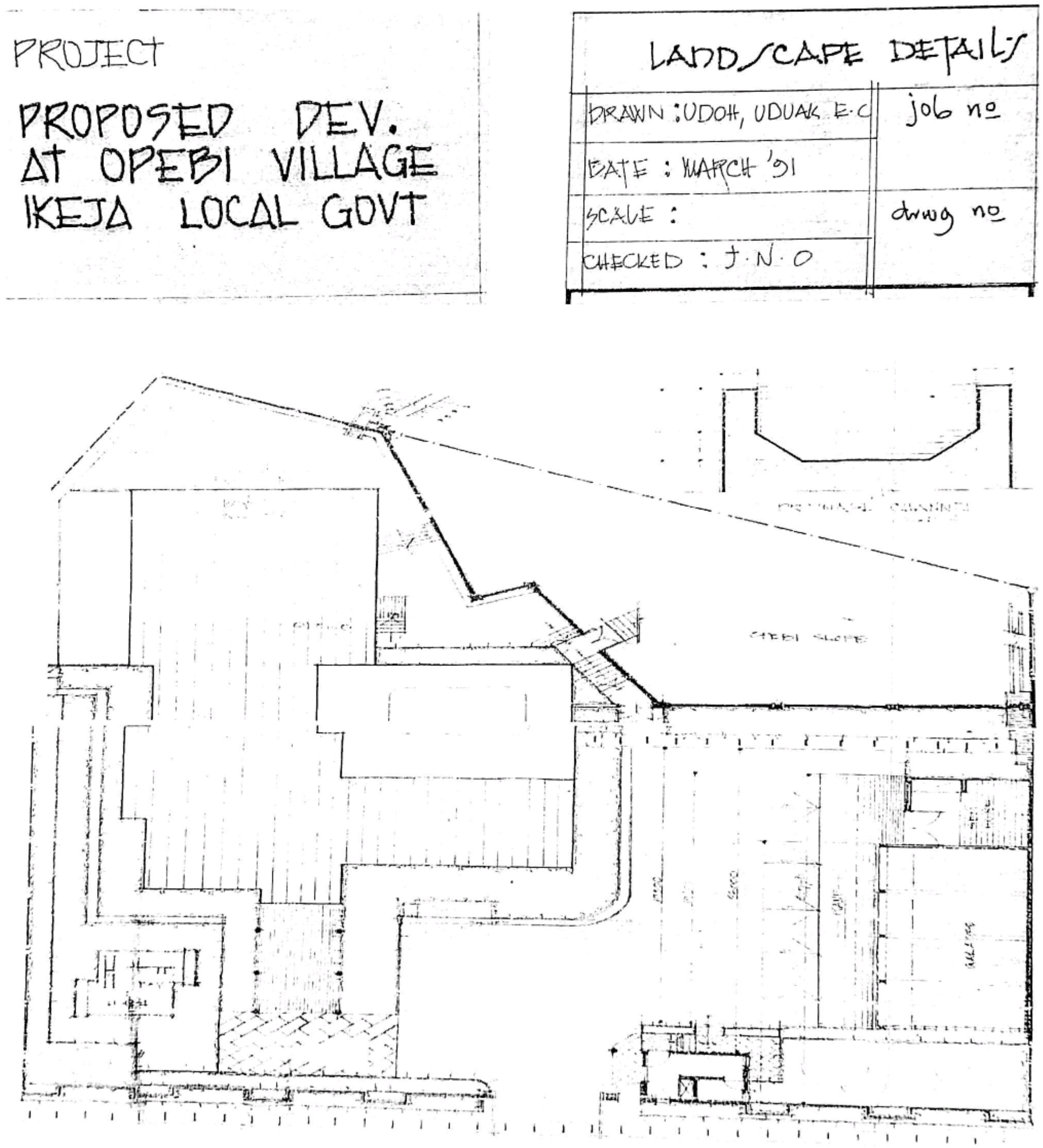


Fig. 1 The site plan

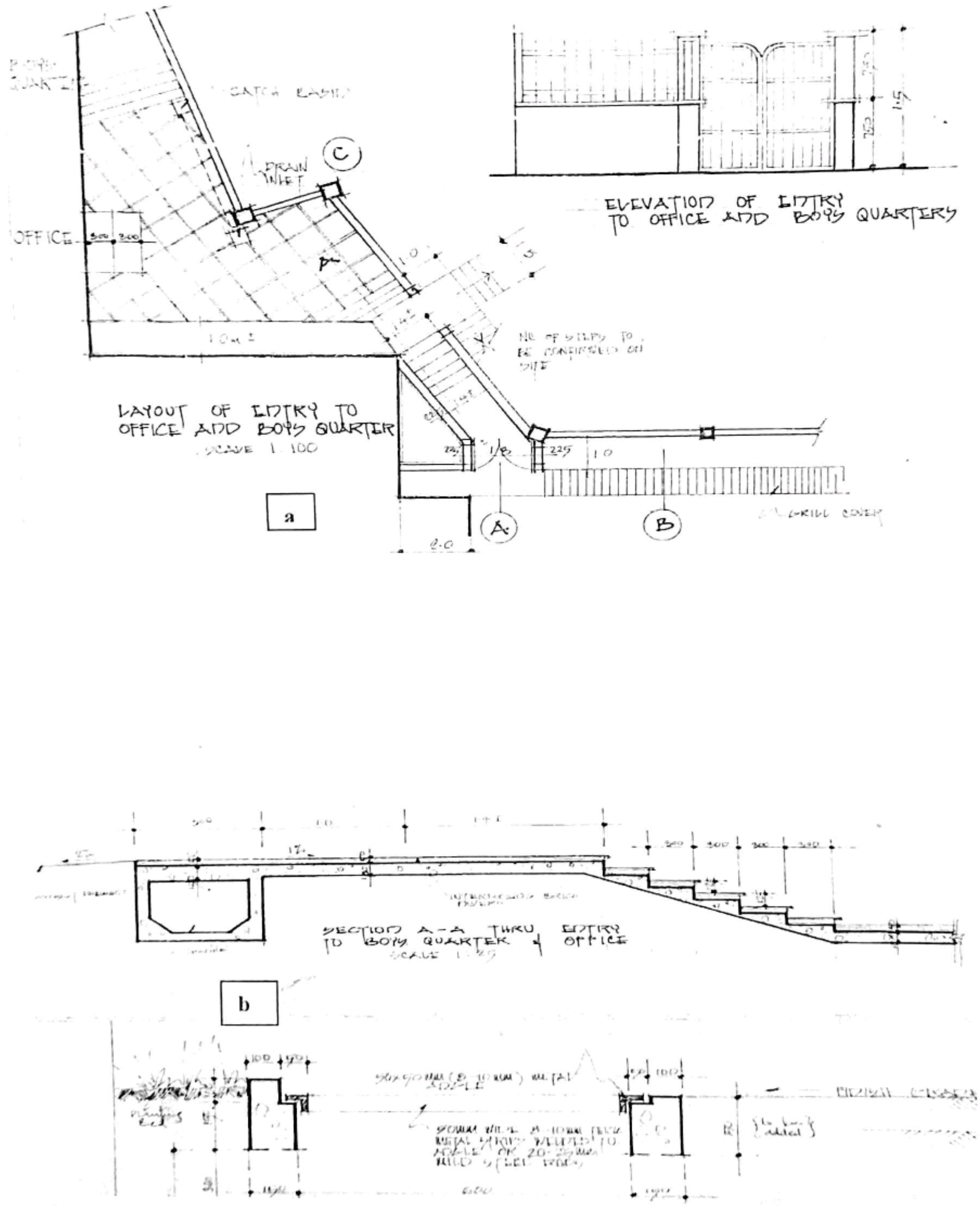


Fig. 2a,b. Access to the office and BQ through a combination of steps and landings plus sections.

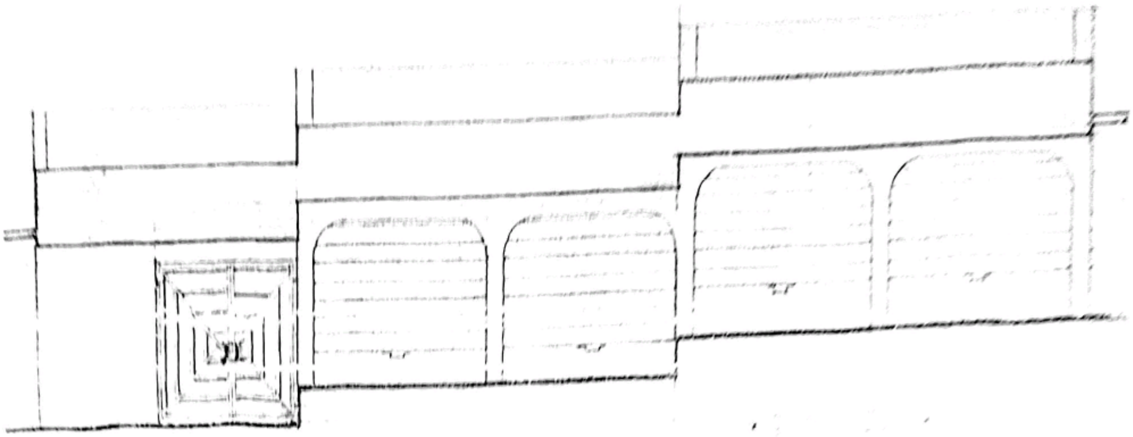


Fig. 3. Shows the terracing of the generator shack from the garages with secondary interceptor channel located between them.

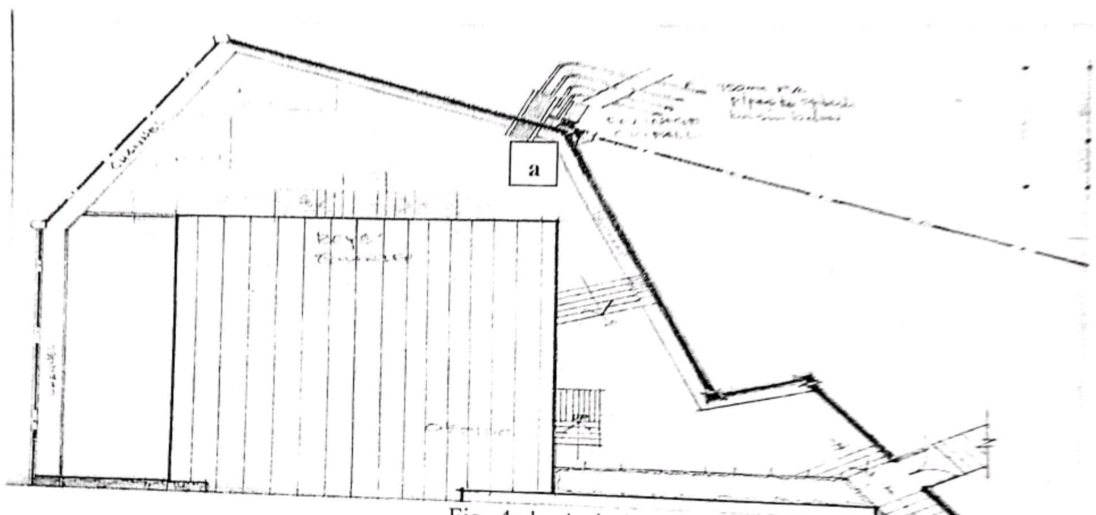
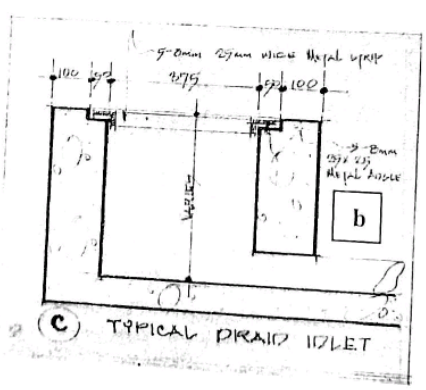


Fig. 4a,b. A drainage outfall to the gorge located next to the BQ (a) and a typical section of the drop inlet (DI) used (b).



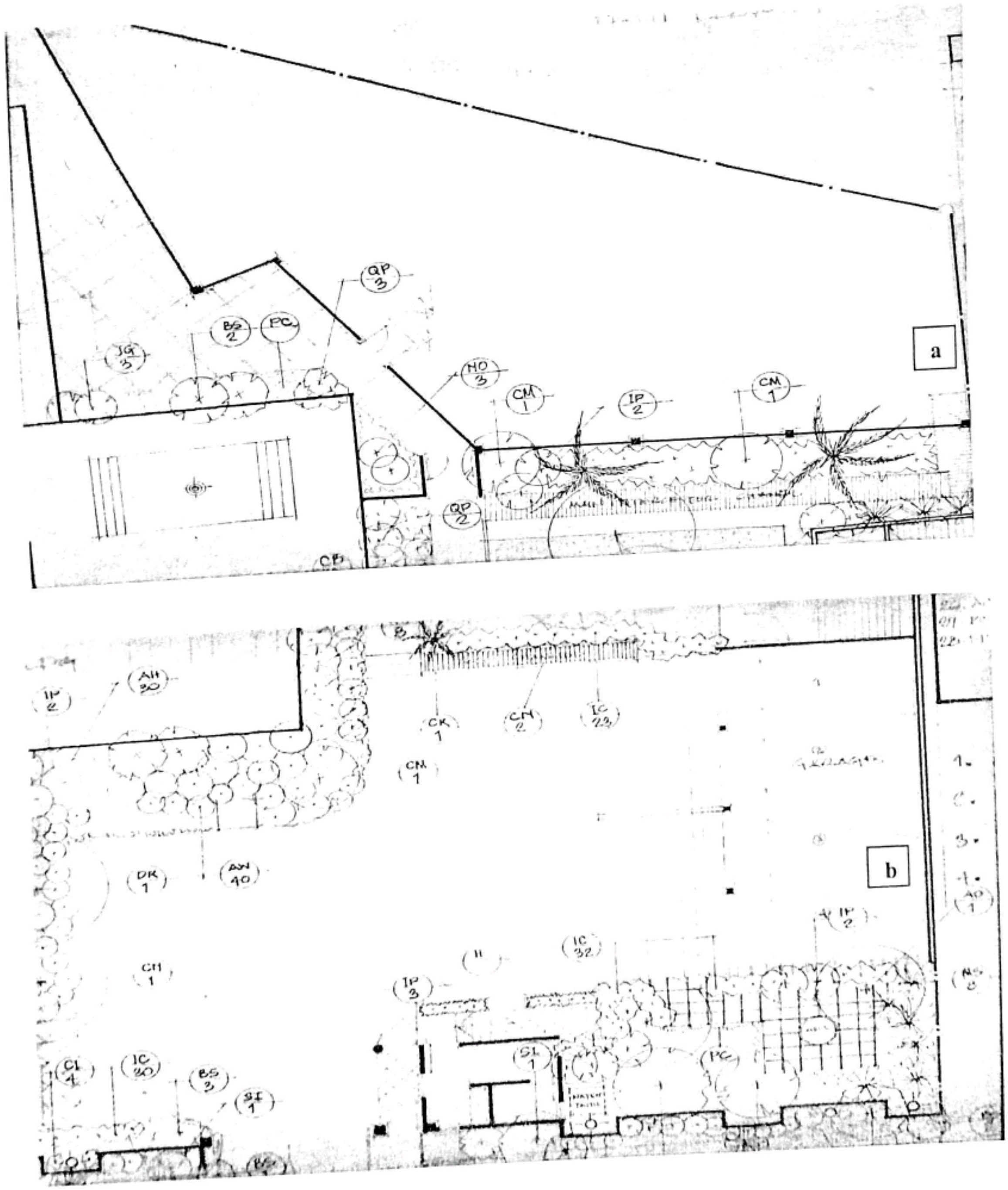


Fig. 5a, b. Planting plan for the residence

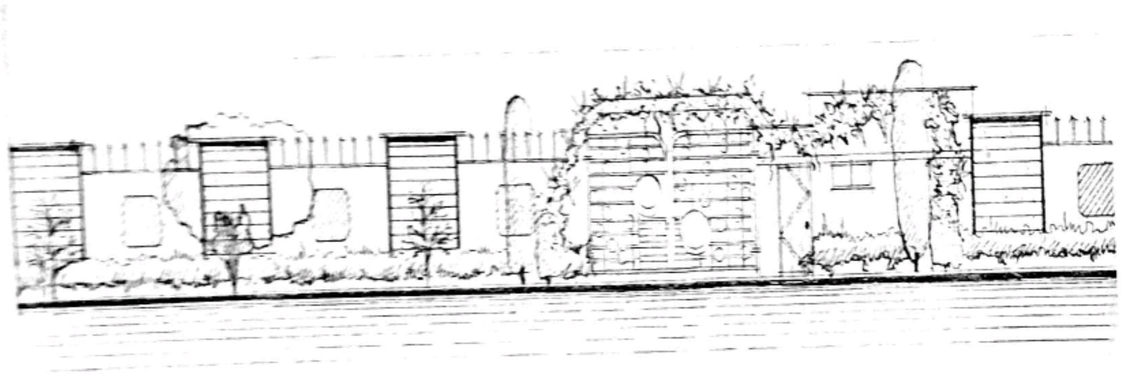


Fig 5c. Planting plan for front fence and was faithfully implemented.