

Species Selection and Design Principle of Rock Garden: A Case Study of the Rock Garden in Shanghai Chenshan Botanical Garden

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Abstract: A rock garden is an integrated combination of rocks and plants selected to enhance both the cultural and aesthetic quality of the garden. To satisfy both the aesthetic and cultural requirements, a plant must be relatively low growing and have a growth habit that complements the natural effect of the rocks. The first Rock garden in China could trace back to Lushan Botanical garden, which was built in 1930s. This paper aims to investigate a recent constructed rock garden in Chenshan botanical garden and explore design principle of rock garden in China. The field investigation was conducted by two graduate students of Nanjing Forestry University in June, 2013. A base map was prepared to divide the site into zones to study. And the two researchers walked the entire study area to make sure the interior reliability of all observed species.

The results indicated overall the growing condition for most species are good or fair while only a limited number of species are poor. Site selection, drainage, site background, rock selection, and planting design are all important factors for design principle of rock garden. The case study suggested that as a courageous attempt for abandoned quarry renovation, the rock garden in Chenshan Botanical Garden has successfully responded to various challenges and displayed the following characteristics: restoring the ecology of quarry, creating natural and cultural experience of oriental style and applying highly-difficult construction techniques. The success of the rock garden in Chenshan Botanical Garden also illustrated a new trend of garden design in post-mining site. It is hoped that more small-scaled rock gardens are proposed with application of local rocks in the future landscape designs in China.

Key-words: Rock Garden; Plant Selection; Design Principle, Planting Design

1. Introduction

The rock garden as we know today, together with its peat banks, screes and bogs, is generally considered as the newest art in the long history of gardening. Even though rock gardens have been in existence for many years, the concept of rock gardening is confusing to many people. In a pure sense, a rock garden could be any collection or display of rocks, excluding plants altogether. The Japanese practice this type of rock gardening by artistically incorporating only rocks and sand. However, the English style of rock gardening is most commonly associated with the term. Begun in England in the late 1800s, this style of gardening focused on creating an ideal growing site for alpine plants, constructed so as to produce a landscape effect [1]. Aesthetic quality increased as alpine gardening evolved, and rock gardens became more naturalistic in appearance. Garden designs attempted to capture the character and feeling of a mountain scene. Gradually, many excellent plants besides true alpines were introduced into the gardening as we know it today was born [2]. In short, a rock garden is an integrated combination of rocks and plants selected to enhance both the cultural and aesthetic quality of the garden [3].

The term "rock garden plant" is used to classify a broad group of horticultural plants that can be associated with rocks in an aesthetic and culturally correct manner. To satisfy the aesthetic requirement, a plant must be relatively low growing and have a growth habit that complements the natural effect of the rocks [4]. To be culturally correct in a rock garden, a plant must be able to thrive in the unique microenvironments created by the rocks. Cultural factors include shard drainage, a cool root run, and protection of the foliage from splashing mud. Alpine plants make up the majority of the group of rock garden plants. Although not normally considered to be rock garden plants, a few lowland wildflowers meet the aesthetic and cultural requirements and can also be classified in this category. Table 1 lists typical rock garden plant types and the habits (Wang, 1989).

Although rocks are widely used in traditionally Chinese Gardens, Lushan Botanical garden is the first Rock garden in China, which was built in 1930s (Tang, 2006). This paper aims to investigate a recent constructed rock garden in Shanghai Chenshan botanical garden and explore design principle of rock garden in China.

Table1: Summary of Common Rock Garden Plant type and Characteristics

Plant type	Common Genus Or Species	Habit and Characteristics
Bryophyte	Chiloscyphus;Lophocolea; Heteroscyphus;Plagiochila; Marchantia;Dumortiera	Vary in size from a length of 20 cm and a breadth of 5 cm; Most gametophytes are green; Bryophytes form flattened mats, spongy carpets, tufts, turfs, or festooning pendants.

		These growth forms are usually correlated with the humidity and sunlight available in the habitat.
Pteridophyta	Lycopodium; Selaginella; Osmunda; Adiantum; Pyrrosia; Pseudodrynaria Drymoglossum; Pteris	Ferns are usually found in border habitats that other plants find hard to survive in. They grow in rock crevices, deserts, on mountains and in moist and shady forests.
Carboniferous	<i>Sabina procumbens</i> <i>Cryptomeria fortunei</i>	Mostly are dwarf pines and cypress; creeping along rocks to grow
Angiosperm	Asarum; Iberis; Gentiana; Orunyka; Viburnum; Abelia; Ardisea; Hypericnti; Rosa Cotoneaster; Pyracantha; Spiraea	Mostly are Alpine plants; Highly aesthetic value

2. Method

Case study is an empirical inquiry that investigates a contemporary phenomenon within the real context (Groat and Wang, 2002). In order to explore species selection and design principle of rock garden, we conducted a case study of the Rock Garden in Shanghai Chenshan Botanical Garden.

2.1. Study Area

Climate

Shanghai has a humid subtropical climate and experiences four distinct seasons. Winters are chilly

and damp, and cold northwesterly winds from Siberia can cause nighttime temperatures to drop below freezing, although most years there are only one or two days of snowfall. The city averages 4.2 °C in January and 27.9 °C in July, for an annual mean of 16.1 °C. Shanghai experiences on average 1,878 hours of sunshine per year.

Site Context

The Rock Garden is a part of Quarry Garden, located in the northern part of Shanghai Chen Mountain Botanical Garden (Fig.1). Renovated from abandoned quarry yard, Quarry Garden has become one new landmark and name card of

Shanghai. Its capabilities are fully displayed based on ecological restoration and culture reconstruction strategies. One dangerous inaccessible abandoned land has been built into one attractive tourist resort for visitors approaching natural landscape and experiencing the culture of quarrying industry.

Quarry Garden has been divided into three parts: the Lake Area, the Platform Area and the Deep Pool. The Rock Garden is situated between the terrace area and the hills. The rock garden is consisted of several different zones: key feature zone, desert

zone, flower slope zone, hilly meadow zone, and alien plants zone (Fig.2). The exits and entrances are connected by three layers of set-back floors with retaining wall; the set-back floor is grown with a single variety of bushes. Overall, the Planting design integrates vegetations, rocks and retaining walls perfectly. First, the designer utilizes the free stone wall and the rusty steel plate to reshape facade sequence with rhythmic changes. Second, a variety of mountain-climbing routes are explored for people to reach the top of the Platform and to visit the “secret garden” of diverse plants.

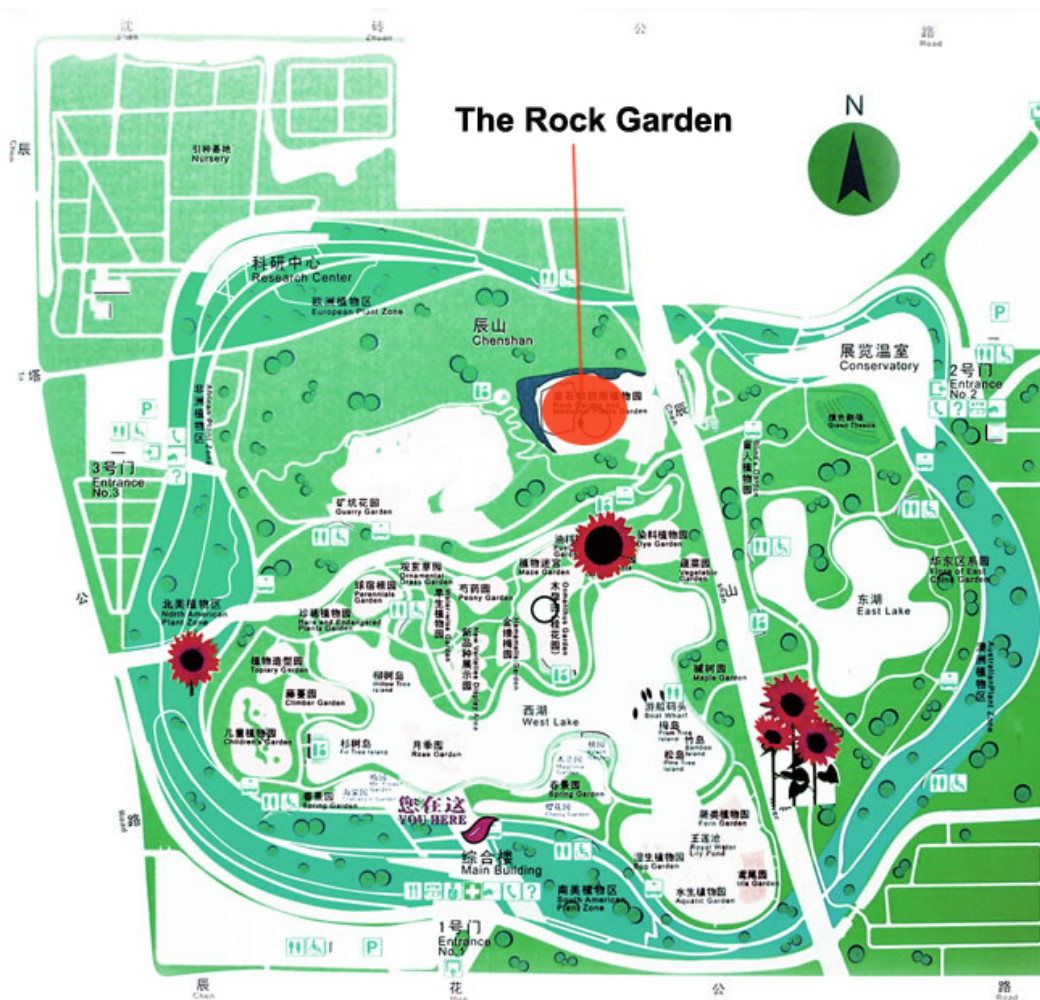


Fig.1: Location of the Rock Garden in Shanghai Chen Mountain Botanical Garden



Fig.2: Plan of the Rock Garden

2.2 Data Collection

In order to be familiar with the site and to make the field investigation more efficient, a pre-investigation was carried out through literature reviews and the internet search. Then the field investigation was conducted by two graduate students of Nanjing Forestry University in April, 2013. A base map was prepared to divide the site into zones to study. One student is in charge of taking photos; the other one is in charge of recording plant species and their growing conditions. The two researchers walked the entire study area to make sure the interior reliability of all observed species.

3. Results and Discussion

3.1 Species Selection

Totally we observed 71 species, which were grouped into four growing types: arbor, shrub, vine, and herb (Table 2). These included both preserved and designed plants. Overall the growing conditions for most species are good or fair. Only a limited number of species are poor. For arbors, 8 species are good and 2 species are fair; while only 2 species are poor: *Olea europaea* and *Malus hupehensis*. For shrubs, 16 species are good and 2 species are fair; while only 1 species is poor: *Serissa japonica*.

cv. 'Variegata'. For vines, 4 species are good and 1 species is poor: *Serissa japonica* cv. 'Variegata'. For herbs, 17 species are good and 11 species are fair; while 7 species are poor. The main reason for these species in poor growing condition is the unscientific introductions from different planting zones. As we know, *Cycas revoluta* is a tropical species but the winter temperature in Shanghai is sometimes below 0 degree. That could explain why the growing condition of *Cycas revoluta* is poor.

Table2: Summary of Observed Species and Growing Condition

Type	Scientific Name	Growing Condition
Arbor	<i>Pinus thunbergii</i>	Good
	<i>Acer palmatum</i>	Good
	<i>Olea europaea</i>	Poor
	<i>Cupressus glabra</i> 'Blue Ice'	Good
	<i>Sabina virginiana</i>	Good
	<i>Malus hupehensis</i>	Poor
	<i>Osmanthus fragrans</i>	Good
	<i>Ulmus pumila</i>	Good
	<i>Sabina chinensis</i> cv. Pfitzeriana	Good
	<i>Torreya grandis</i>	Good
<i>Tamarix chinensis</i>	Poor	
<i>Yucca elephantipes</i>	Fair	
Shrub	<i>Mahonia confusa</i>	Good
	<i>Nandina domestica</i>	Good

	<i>Temstroemia gymnanthera</i>	Good
	<i>Camellia japonica</i>	Fair
	<i>Eurya emarginata</i>	Good
	<i>Ilex cornuta</i>	Fair
	<i>Hibiscus mutabilis</i>	Good
	<i>Elaeagnus argyi</i>	Good
	<i>Callicarpa bodinieri</i> 'Purplepearl'	Good
	<i>Indigofera fortunei</i>	Good
	<i>Pyracantha fortuneana</i> 'Harlequin'	Good
	<i>Euonymus japonicus</i>	Good
	<i>Serissa japonica</i> cv. 'Variegata'	Poor
	<i>Viburnum tinus</i>	Good
	<i>Daphne odora</i>	Good
	<i>Syzygium buxifolium</i>	Good
	<i>Sabina procumbens</i>	Good
	<i>Cotoneaster horizontalis</i>	Good
	<i>Cycas revoluta</i>	Good
Vine	<i>Trachelospermum jasminoides</i>	Good
	<i>Ficus pumila</i>	Poor
	<i>Hedera nepalensis</i>	Good
	<i>Euonymus fortunei</i>	Good
	<i>Spora lygodii</i>	Good
Herb	<i>Kniphofia uvaria</i>	Poor
	<i>Hemerocallis fulva</i>	Good

<i>Chrysanthemum maximum</i>	Good
<i>Penstemon laevigatus</i>	Fair
<i>Gaura lindheimeri</i>	Fair
<i>Perennial chamomile</i>	Good
<i>Coreopsis grandiflora</i>	Fair
<i>Hemerocallis citrina</i>	Good
<i>Tradescantia reflexa</i>	Fair
<i>Verbena bonariensis</i>	Poor
<i>Verbena hybrida</i>	Good
<i>Echinacea purpurea</i>	Fair
<i>Althaea rosea</i>	Fair
<i>Hibiscus moscheutos</i>	Good
<i>Anisodonteia capensis</i>	Poor
<i>Polygonum runcinatum</i>	Good
<i>Artemisia vulgaris</i>	Fair
<i>Sedum sarmentosum</i>	Good
<i>Sedum sieboldii</i>	Fair
<i>Sedum spectabile</i>	Good
<i>Hydrocotyle vulgaris</i>	Good
<i>Bletilla striata</i>	Poor
<i>Lycoris radiata</i>	Good
<i>Platycodon grandiflorus</i>	Good

<i>Narcissus tazetta</i>	Poor
<i>Polygonatum odoratum</i>	Fair
<i>Dysosma difformis</i>	Good
<i>Dracaena deremensis</i>	Poor
<i>Aloe vera</i>	Good
<i>Yucca gloriosa</i>	Good
<i>Miscanthussinensis</i> 'Variegatus'	Fair
<i>Pennisetumalopecuroides</i>	Good
<i>Stipalessingiana</i>	Poor
<i>Carexristachya</i>	Fair
<i>Carexshimensis</i> 'Evergold'	Good

3.2 Design Principle of Rock Garden

The Rock Garden in Chenshan Botanical Garden (Fig. 3) is the naturalistic rock garden, yet the most difficult type of rock garden to design and construct. Its basic purpose is to recreate a natural setting where rock garden plants will look and grow their best. Many people think that a natural rock garden can be constructed in a haphazard manner without regard to basic design principles. This misconception has led to the creation of more rock piles than rock gardens. Studying rock formations in nature is a prerequisite to understanding natural rock garden design and construction.



Fig.3: Bird's View of the Rock Garden

(1) Site Selection

Site selection should be a primary consideration before designing and building a rock garden. Important criteria for evaluating potential sites are exposure, drainage, background, natural features, and existing architecture. As abandoned quarry mountain with exposed rock and hillside (Fig.4), Chenshan Mountain is an ideal site for rock garden construction.



Fig.4: Abandoned Quarry

(2) Drainage

Drainage is the single most critical factor in site selection. Most rock garden plants require excellent drainage for successful cultivation. A well drained environment can be obtained only if the original site has good drainage. In this case, one deep pool is preserved in the west quarry providing natural drainage for the rock garden in the east side.

(3) Site Background

Site background is important in capturing the beauty of a rock garden. A naturalistic rock garden should

not be built near architectural or natural backgrounds. The most desirable background is composed of a combination of conifers, broadleaved evergreens, and deciduous trees and shrubs. The contrasting foliage textures of these plants will provide depth and interest year round. If a suitable background does not exist, allow adequate space in the basic design for planting one. The depth of the background is variable, but it should be at least two plants deep. Planting should follow an informal arrangement, not a formal hedge planted in straight rows. The skyline created by the background should be irregular to enhance the natural effect of the garden.

In this case, the restored quarry hill with both preserved and designed plants provides a desirable background for the rock garden (Fig.5). Beside, on the other side, several preserved cinnamon trees are also excellent background of the rock garden (Fig.6).



Fig.5: Restored Quarry Hill as Background



Fig.6: Preserved Trees as Background

(4) Rock Selection

Choose a type of stone on the basis of availability rather than aesthetic qualities. One type of stone, not a mixture of different types, should be used throughout. Avoid the temptation to include exotic, shiny, or colored stones. Rocks with a weathered face are preferred to rocks that have been cut or broken. Another common problem is the use of too many small rocks. The garden design should be based on a few large rocks strategically placed to create a naturalistic effect. Many small stones produce a busy appearance at best. Generally speaking, any rock that can be easily handled by one person is too small to be used as part of the backbone rock formation.

In this case, many rocks are used to enclose flower beds along the existing landform (Fig.7). The maximal height difference is almost 10 m. So, retaining walls are built at steep slopes. Also, most selected rocks are relatively large stones.



Fig.7: Typical Stones

(5) Planting Design

The design takes into consideration time of bloom, flower and foliage color, and plant shape. Its objective is to coordinate colors and arrange plants by blooming periods for a uniform display of flowers throughout the season. Several basic design principles unique to wall gardens should be considered. One of the most common mistakes in planting a wall is over planting. Much of the beauty of a wall garden is derived from the contrast of rocks and plants. Do not plant in straight rows or columns, but preferably in irregular masses, leaving ample portions of the wall exposed. Another factor that is often overlooked is planting above and below the face of the wall to add depth and interest to the wall garden. Allow some of the mass plantings to spill over and continue along the top and bottom of the wall. The top of the wall can also be planted with a few dwarf conifers to provide year-round interest.

In this case, various vines and herbs are randomly planted between rocks to restore and decorate the site. For example, a large number of sedums are applied along rocks to mimic alpine landscape (Fig. 8). Besides, a significant artificial meadow with

rocks as the foundation is constructed in the center of the rock garden (Fig. 9).



Pic.8: Alpine Landscape



Pic.9: Artificial Meadow

3.3 Limitation

There are some limitations in this study. First, the field investigation only recorded names of plant species and the growing conditions. More detailed information, such as size and number of species are needed in the future study. Second, this paper only investigated one rock garden to demonstrate design

principle. In the future research, multiple case studies in different regions of China are needed to explore the general design principle at various geographical contexts.

4 Conclusion

As a courageous attempt for abandoned quarry renovation, this rock garden in Chenshan Botanical Garden has successfully responded to various challenges and displayed the following characteristics: restoring the ecology of quarry, creating natural and cultural experience of oriental style and applying highly-difficult construction techniques. The quarrying industry has stripped the vegetation cover on the surface layer and altered the landform significantly, causing water and soil loss as well as habitat fragmentation. Taking advantage of existing rock ground, the rock garden collected several common rock garden plant species from east China to restore and decorate abandoned quarry mountain. Most applied species are relatively hardy to extremely conditions. Instead of attempting to build up a traditional forest or green space, the design strategy is to reshape the land form and to increase vegetation cover with minimal cost. The success of the rock garden in Chenshan Botanical Garden illustrated a new trend of garden design in post-mining site.

China is a mountainous country with plenty of wild and alpine vegetation resource [7]. The construction of rock garden has significant contribution to the collection, preservation, education and also scientific research of vegetation resource. Compared to the Western countries, the rock garden design in China is still developing, but becoming more and more popular in recent years. The current

challenge is how to integrate the Chinese landscape characteristics into rock garden design. It is hoped that in the future landscape designs more small-scaled rock gardens should be proposed with the application of local rocks. For example, the green roof is an ideal context of applying rock garden.

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