Design and Construction of the Flood Diversion Channel of Sogi Falls

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Abstract: The flood diversion channel of the Sogi Falls is a groundbreaking disaster restoration civil engineering work benefiting a wide range that pans out from natural disaster prevention, improving the quality of life of the local residents to increasing the aesthetic value of the landscape as a tourism resource, despite the emergency situation at the design and implementation stages. As a result, this project was chosen for the ‘Good Design Sustainable Design Award’ in 2012.This paper reports an overview of the project from the initial disaster situation through the design process and construction to the utilization of the diversion channel and discusses it from the viewpoint of temporalities that civil engineering design holds. We conclude that civil engineering design is presumed to hold three temporalities: historical, daily and mythical time.

Key words: Landscape design, Civil engineering, Disaster prevention, Diversion channel

1. Introduction

The effects of disaster restoration works on the formation of the landscape are considerable in Japan, a country where natural disasters frequently occur. Those projects require speed and efficiency as well as improvements in disaster prevention, and so landscape, environment, and local community factors generally tend to be overlooked.

On the other side, landscape design is not limited to the landscape architects in Japan, and even civil engineers take the lead on a project sometimes. It is quite a unique approach, and it may be due to our perception of the world that nature and art are blended together with no rigid boundary between them. Landscape design is very complicated as well as being interdisciplinary, so ideally the various experts need to collaborate and learn from each other for the sake of the landscape, especially civil engineers; the infrastructure designed by them has a strong influence on the landscape.

The ‘flood diversion channel of the Sogi Falls’ in Isa City, Kagoshima Prefecture is a groundbreaking disaster restoration civil engineering work benefiting a wide range that pans out from natural disaster prevention and improving the quality of life of the local residents, to increasing the aesthetic value of the landscape as a tourism resource, despite the emergency situation at the design and implementation stages. (Figure 1) As a result, this project was chosen for the ‘Good Design Sustainable Design Award’ in 2012 (http://www.g-mark.org/), evaluated thusly: ‘The result of creating a naturalistic river space, creating an amenity and giving new value to the local area beyond recovery from a natural disaster is epoch-making.’ We have already reported an overview of this project. [1-2] So this paper reports the process in detail, from the initial disaster situation through the design and construction to the utilization of the diversion channel, and discusses it from the viewpoint of temporalities that civil engineering design holds.

2. Summary of the project

There was record breaking heavy rain around the R. Sendai area in north Kagoshima Prefecture in July 2006. The scale of this huge disaster was thus: 5 casualties, 32 destroyed or washed away buildings, inundation above floor level in 1,848 buildings, inundation below floor level in 499 buildings, and the area of inundation was 2,777 ha. Sogi Falls in Isa City, the site of this project, dammed up the flow and caused the flood in the upper stream. (Figure 2)

To restore this severe damage, a 'Directly Controlled Special Emergency Measure for the Seriously Damaged River (commonly known as: Emergency Project for Serious Damage)' was adopted. This project had a huge area and budget, and the construction in the Torai area, Satsuma town, and Sogi area, Isa City, was larger than any other construction in this project. (Figure 3) The 'flood diversion channel of Sogi Falls' is the construction in the Sogi area. The prepared flood diversion channel is 400m in length, 30m wide. The water volume of July 2006 had a total of 3,900 m^3/s as the estimated maximum flow, of which 3,700 m^3/s is to be borne by the present river and the remaining 200 m^3/s to be diverted to the new channel. It was completed in March 2011. (Figure 4)

On the other hand, the 'Sogi Falls' nearby this channel is 210m wide and with the highest difference in elevation being 12m is one of the largest waterfalls in Japan. (Figure 5) It was listed as one of the best 100 scenic beauty spots in 2009 (ranked 24th). The falls receive around 300,000 annual visitors, the majority of whom mostly limited their visit to a brief stop. As it is adjacent to a tourist spot, consideration for the landscape was valued from the beginning of the project, and the 'Committee for the Consideration of the Landscape of the Flood Diversion Channel of Sogi Falls' was established in July 2007 consisting of experienced academic experts and local residents.

Figure 1. The flood diversion channel of Sogi Falls（seen from downstream）

This is not a natural stream, but an artificial channel for flooding made by blasting and excavation with dynamite.

Figure 2. The flood in 2006

Project period : 2006~2011
The total construction cost : about 37.5 billion yen. (Costs of National Government : 35 billion yen)
Project places : 41 places
(Government construction: 37, Kagoshima Prefecture construction: 3, Miyazaki Prefecture construction: 1)
Main Projects : Embankment, River channel digging, Development of diversion channel,
Rebuilding of the bridge (4 bridges)

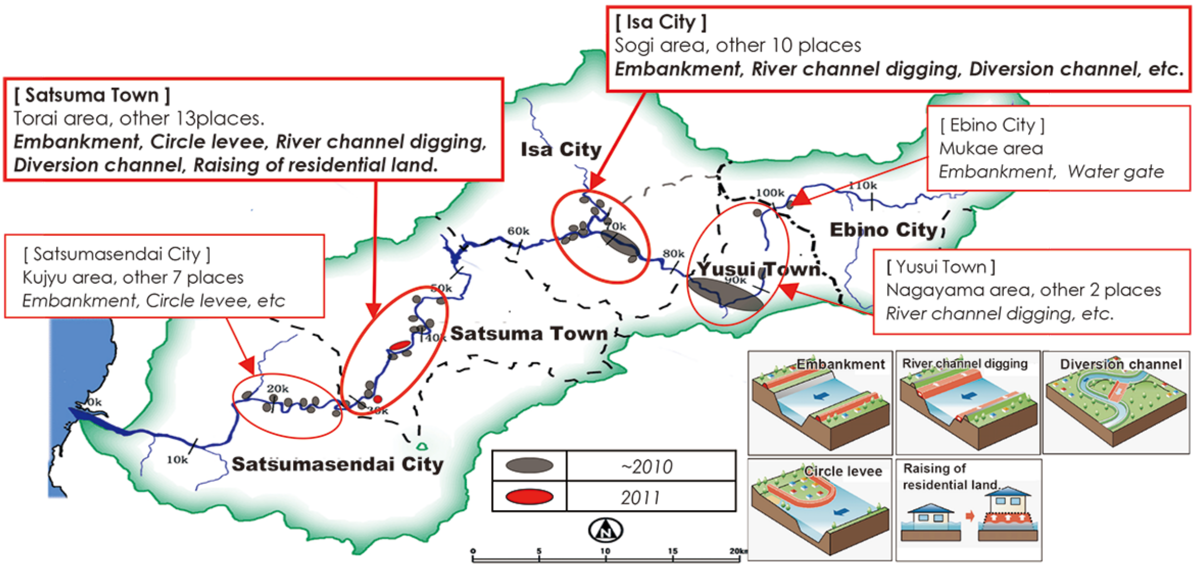

Figure 3. Overview of the 'Emergency project for serious damage' of River Sendai

Figure 4. Aerial photo after the improvement works

Figure 5. Sogi Falls Landscape

2. Process of design

2.1 Making concept

That the Sogi Falls was the main cause of the upstream floods was well known, so a flood diversion channel had already been planned in 1988. But there was concern about the plan destroying the scenic beauty of the falls and so nothing had been done for a long time. At first, we started discussing the existing plan. The plan suggested piercing a rather brutal and ordinal 60m wide and 700m long concrete molded channel. (Figure 6) In the beginning of discussions, there were a lot of opinions that held the landscape in a narrow sense, for example, how to treat the surface of the diversion channel, etc. But it is very important in making a good landscape that the project is linked to the whole area and the residents' lives. Landscape design is not only prettifying make-up. So we tried to share the various functions of the diversion channel through making a model of the whole area and sketching images of people using the diversion channel.

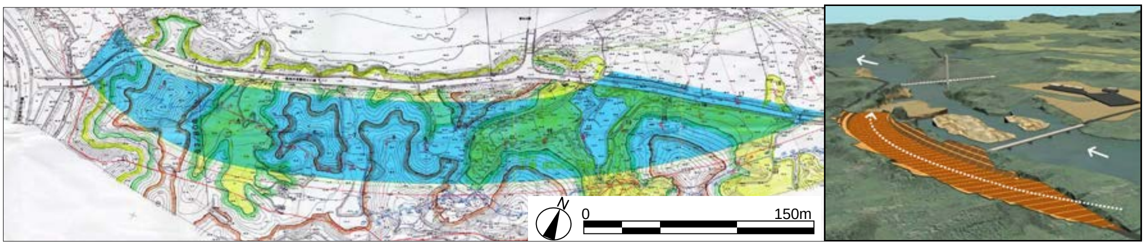

Figure 6. The existing plan from 1988

The most impressive opinion from the residents was about a sense of security. 'Sogi Falls' is the cause of flooding for the residences in the upper stream. So one resident said that if the diversion channel has a stream on a daily basis, she would get a sense of security every day. I think that the ideas like this are one of the various values given from the diversion channel. Through these discussions, we made the concept for utilization. It was considered and listed as follows.

1. Little stream: letting a small amount of water (irrigation for the surrounding farmland) permanently flow like a little stream in the channel, which is normally in use only in case of flooding. This makes it possible to visualize that the channel is a natural disaster prevention device in emergency, contributing to making the locals feel secure, as well as increasing amenity value and bio-diversity as a play area and biotope.
2. Encouraging rambling activities: The user-friendly space is easy to wander about in and it is crucial that the route itself is pleasant. The inspection passage was made to follow the changes in the geological stratum, changing levels and widths and avoiding straight lines. Steps were placed in suitable locations in terms of flow line and geology.
3. Finish of the river floor: the walk-able river floor primarily follows the diversion channel's spatial framework, gently zoned into upper, middle and lower streams, and the variation of areas was enhanced by the appearance of streams and uneven rock surfaces.

2.2 Technical design

The design for the restoration work was selected from among three options after careful consideration with hydraulic analysis; the plan was chosen for its cost effectiveness, the least amount of environmental impact to the site, and hydraulically rational and stable function. Specifically, the complicated mountainous landform of the site was to be preserved as much as possible creating the channel to follow the undulation by a naturally meandering course, as long as it was concealed from visitors' view at the Sogi Falls Park.

A simple model was made to study the three-dimensional space retaining speed and efficiency. The series of sectional models was useful for sharing spatial information about the interior space and rising elevation of the diversion channel among specialists in different areas such as river engineers and landscapers. The models present the basic quality of landscape as a 'view of the environment at eye-level', as well as a hydraulic analysis of the river at a glance, and it was an essential tool for good communication. (Figure 7) The final model was shared with local residents, after being modified by filling in clay between the series of sections. (Figure 8)

Figure 7. Discussions with administrative officials and river engineers

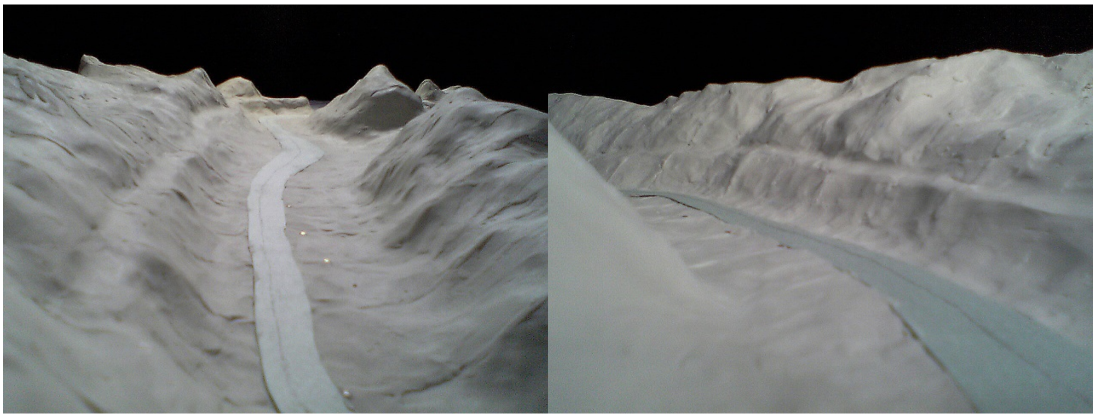

Figure 8. Clay model of the final design（1/500）

Through the corroboration of hydraulic analysis and landscape design, we changed some hydraulic specifications as follows:

1. Longitudinal slope: We changed the longitudinal slope from about 1/1400 (the slope of the planned high water bed) in the existing plan to about 1/120 (slope of the river bed). If the slope were steeper, the flood water could run easily and quickly and we could make the channel narrower.

2. Bed roughness: The roughness of the Todoroki narrow pass, the existing rock excavation in R. Sendai, was verified as 0.035 in this disaster. So we could change the bed roughness from 0.045 as a scraggy rock excavation to 0.035 as a smooth rock excavation.
3. Correspondence for shooting flow: We confirmed the shooting flow could occur in the narrow section of this channel. As a result of discussions, we admitted the shooting flow itself, and did minimum widening for preventing a big hydraulic jump.

3. Process of construction

3.1 Outline of construction

Challenges at the design stage such as stabilization of the slope and the finish of the rock excavation continued on into construction, and that required constant thinking during creation. The construction area was divided into two at the center point, the upper and lower streams, and excavation works were made in three phases (Figure 9); parts which were difficult to illustrate on the drawings were shown by the submitted clay model and were frequently discussed at design management meetings with the 6 contractors involved. (Figure 10)

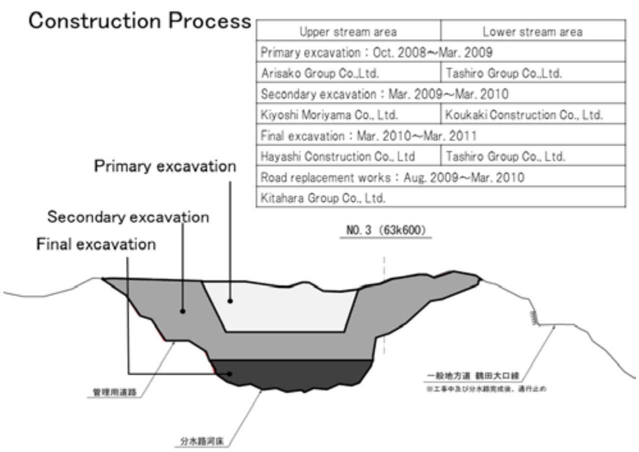

Figure 9.　Construction process

Figure 10.　A meeting on the channel floor finish using the model

3.2 Devising construction

3.2.1 Primary excavation

The primary excavation was more like a trying out of design ideas and collecting various data (actual topographical features and various textures of the rock surface with different finishes, etc.), for referral later on and in the final phase.　Sharing information with authorized people on-site as work went on was particularly important.　As a result, a variety of finishing methods were exhibited and we were able to choose the best one. The excavation was on 5m above the finished river floor level. (Figure 11)

3.2.2 Secondary excavation

Excavation progressed down to a few meters above the finished river floor level, and formed the slope of the embankment.　The view of the diversion channel was formed at this stage.　Taking the results of the primary excavation but not totally relying on the plans or drawings, the natural look finish was brought about by excavation and blasting dynamite in accordance with the rock joints. In order to achieve the natural look, the local contractor contrived to attach a brush to the top of the backhoe, and carefully removed fine debris. (Figure 12) As regards to planting on the embankment, the recovery of natural vegetation is expected.

Figure 11. Completion of the primary excavation（7th Jul. 2009）

Figure 12. Careful finishing by heavy machinery at the secondary excavation

3.2.3 Final excavation

The final phase is for the finishing touches to the excavation based on utilization assumptions. Making the most of the dynamic rock surface revealed by the blasting dynamite in the previous phase, the finish of the river floor and adequate allocation of flow line that would accommodate various activities were illustrated in sketches and models. In order to deliver the desired finish, the position of the dynamite to blast the rock was carefully modified in 10cm units and a stone walling technique for building steps was practiced on site to blend in with the rock surface. (Figure 13)

Most of the excavated rocks were carried to the other project of the same ‘emergency project for serious damage’ in the Torai area, Satsuma Town, as mentioned before. That project had a lot of stone walls for a new diversion channel and embankment. (Figure 14) We could cut costs for the removal of excavated rocks in Sogi and the purchase of new stone in Torai as a result of the carrying. It was because of that that there were many huge ‘emergency project for serious damage’ projects at the same time.

Figure 13. Steps placed between bedrock and stone walls

Figure 14. The diversion channel and embankment in the Torai area

Figure 15. The 2nd Sogi Discovery Walking event（22nd Jul. 2012）

4. For utilization

This chapter suggests how the restoration works enjoyed working alongside nature, adding aesthetic value to the landscape that in turn leads to promoting tourism, as a result of which it became ‘more than just a restoration work’.

As for utilization, awareness emerged for the need for suggesting uses of such a new local resource as well as the implementation of good design. With this in mind, walking events have been held twice so far, in 2011 and

2012. (Figure 15) This was planned by a collaboration of local NPOs, residents, academic experts and administrative officers. Over 300 people of all generations, ranging from primary school pupils to people in their 80's, participated. It turned out to be a great opportunity to rediscover local resources and nature, promoting food, health and education as well as a recreational opportunity for locals, even going so far as to publish original maps and guide booklets.

As obvious in the photographs and models, this flood diversion channel of the Sogi Falls was designed and built to look as if it has been in place as a real river, and the dynamic landscape is unquestionably worthy of attracting more tourists to the site who would spend more time in the area, which in turn may boost the local economy. Such pleasant side effects only came about through the observation, design and construction methods very sympathetic to nature; as if it has been there from ancient times and would age harmoniously with the surrounding nature for the future.

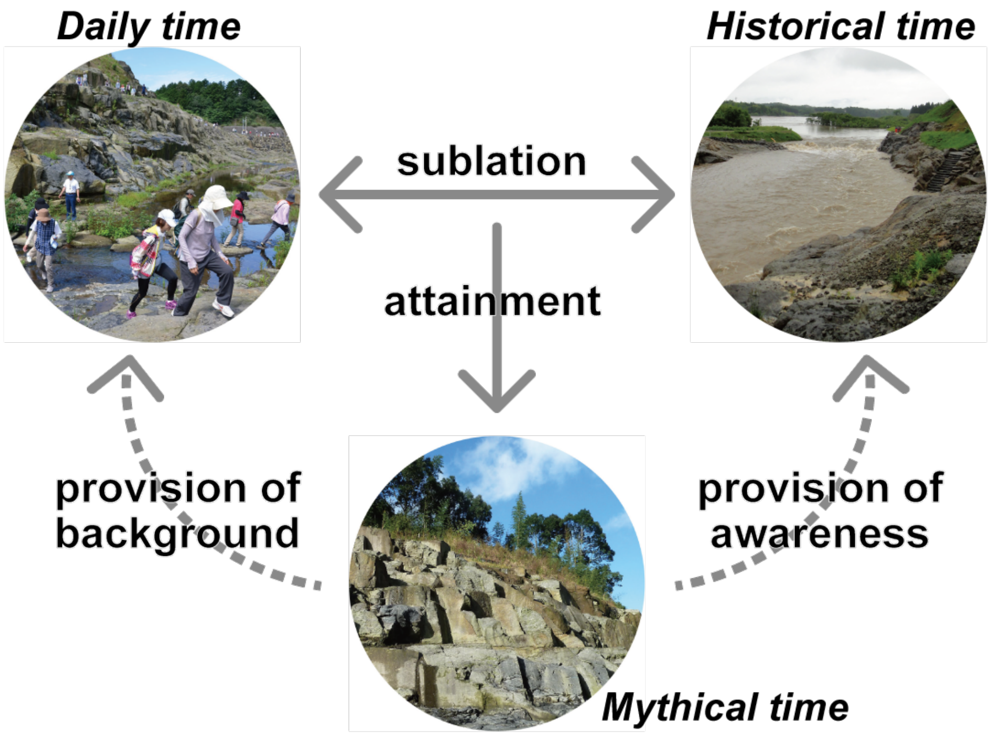

Figure 16. Three temporalities in civil engineering

5. Conclusions: The Time that Civil Engineering Design holds

Hiroshi Naito, an architect who is familiar with civil engineering, said that 'design is interpretation of technology, place and time. The interpretation of time is the most difficult and important'. [3] Civil engineering is not only technological and site-oriented but also holds various time ranges. Finally, we would like to discuss this project from the viewpoint of temporalities that civil engineering design holds.

In short, civil engineering design is presumed to hold three temporalities. (Figure 16) One would be 'Historical time'. The meaning of course includes the history of a site; however to make it simpler, 'a time where cause and effect can be traced, keeping a certain length of time'. For example, not only this project but in general river projects, the high-water run-off is decided as 100 years, or 30 years possibility; that is, so to speak, that the cause and effect is traceable within the specified time scale and foreseeable. On the other hand, in terms of landscape, daily views and usage are more important. I would like to call this time 'Daily time'. The primary efforts made for the design of the flood diversion of the Sogi Falls was how to find the meeting point of the 'Daily time' of landscape and the 'Historical time' of flood control. Although the actuality was a challenge called an 'event', even the walking event was a part of the efforts to share 'Daily time'. Then, the third and last one is 'Mythical time'. This is for a time scale which is too long to trace the cause and effects, in a way, timelessness. The construction period of the flood diversion channel of the Sogi Falls was maybe to meet such a time, or to dig up the time that was buried and forgotten. As mentioned before, in order to achieve a natural look finish upon construction the work was not restricted by sectional design, instead blasting and excavation with dynamite along rock joints, and it is similar to the volcanic eruption of about 330,000 years ago. The cause and effects of such a time may be traceable in geology, but in general sense, it is beyond historic. Thus the 'Mythical time' is a moment to be met accidentally as well as being something that is always there. What we thought while designing the flood diversion of the Sogi Falls was that surely, attaining this 'Mythical time' through the conflict between the 'Historic time' and 'Daily time' provides a background for daily use and an awareness of disaster risks. So it is the real pleasure of civil engineering design.

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