Green resource planning for large-scale hydropower generation in ecologically fragile plateau areas

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Abstract. Aiming at the hard-to-recover damage to the environment caused by material mining and waste slag in the construction of the project, this paper summarizes the green source planning of a large hydropower generation in Tibet, the dam-type development of large-scale hydropower generation with no mining material yard and no permanent waste slag yard in ecologically fragile plateau area achieved for the first time through reasonable planning and utilization of excavation waste slag. The planning protects the environment and saves engineering investment effectively. The planning which has important social significance and economic value can provide reference for other similar engineering designs.

1. Introduction
The demand for concrete aggregate sources is large, and a reliable source plan is needed to ensure the smooth implementation of the project during the construction of the project. At the same time, a large amount of excavation and waste slag will be generated during the construction of the project, which requires a large number of sites to arrange the waste slag yard, and to ensure that the slag slag meets the requirements of safety, water conservation and environmental protection, a lot of manpower and material resources are required for comprehensive treatment. In order to promote the transformation and healthy development of the building materials industry, the General Office of the State Council issued a document in May 2016, calling for the active use of solid waste such as tailings, waste rock and construction waste to replace natural resources, and the development of machine-made sand, gravel, concrete admixtures and other products [1].

There are not only the above-mentioned problems in large-scale hydropower generation in ecologically fragile plateau area, moreover, the construction project is located on a plateau, the surrounding ecological environment is extremely fragile and once damaged, the recovery is extremely difficult and slow. Therefore, reasonable planning of excavation waste slag can reduce the impact of waste slag and material yard mining on the environment and save project investment. The reasonable planning has important social significance and economic value.

2. General Principles of Green Resource Planning
(1) The project is located on the ecologically fragile plateau area with an average altitude of 3450m, a multi-year average temperature of 9.3 °C, and a multi-year average pressure of 685.5hPa, a large temperature difference between day and night. The temperature is low in winter, and the ecological environment is extremely fragile. The source planning scheme should proceed from the perspective of...
environmental protection, and minimize the damage to the ecological environment caused by the mining of the engineering material yard and the layout of the waste slag yard.

(2) There is a large amount of excavation spoil in the project itself. Under the premise of meeting the quality requirements of the material source, it is advisable to use the excavated material as the source of engineering concrete aggregate and filling material as much as possible. So it saves investment and protects the environment.

(3) According to the characteristics of the project, the main excavation materials for the project are cut-and-cover materials, which are easily polluted and difficult to collect from high-slope excavation. When planning the material source, sufficient loss should be considered according to the actual topography and geology.

(4) The project is located in the mountains and valleys, with limited storage sites for excavation materials, and the time and quality standards of various materials are different. It is necessary to carry out a refined earthwork balance plan in terms of time and space.

(5) According to the quality requirements of various materials, the best quality stone should be used as the concrete aggregate source first, the poorer quality stone can be used as the engineering filling material, and the poor quality stone and soil material can be used for the construction site of the engineering area.

3. Concrete aggregate source planning
(1) Source profile

The sources of concrete aggregates that can be used around the project mainly include engineering excavation materials, natural sand and gravel materials, and quarried stone materials.

The excavation materials of the project are mainly the main body of the project and temporary buildings, and the excavation materials of the stone tunnels, and the excavation materials are mainly the stone excavation. The excavated rock is hard, mainly weak weathering, no strong weathering. The quality of the original rock meets the specification requirements after testing.

About 33km~35km upstream of the dam site, there are natural sand and gravel yards. The sand and gravel materials are distributed in a continuous belt along the river in the form of floodplain, and the rock composition of the yard is complicated. The mud content index of the natural sand and gravel stockyard exceeds the specification requirements. The natural aggregate is a potentially harmful active aggregate. Fly ash needs to be mixed to inhibit the alkali activity of the aggregate. Other indicators meet the specification requirements.

About 24km downstream of the dam site, there is a natural sand and gravel quarry. The topography of the quarry is flat and open. The indicators of coarse and fine aggregates of natural sand and gravel materials meet the specification requirements, and the results of alkali activity testing and analysis show that they are inactive aggregates.

The lithology near the project area is single, and the stone material is distributed in a wide range. Among them, the stone quarry with good mining conditions is located on the inner side of the provincial road about 5.5km downstream of the dam site, with a length of about 200m~350m along the river, and a terrain slope of about 30°~50°. The quality of the original rock meets the specification requirements.

(2) Source planning selection

According to the raw rock quality inspection and concrete performance test results of each material source plan, Except that the natural sand and gravel materials have a mud content that exceeds the specification requirements and are potentially hazardous active aggregates, engineering excavation materials, natural sand and gravel materials, and materials extracted from stone yards near the project area all meet the requirements of the specification. Therefore, the concrete aggregate source is mainly selected from the above three source options.

From the perspective of protecting the environment and saving project investment, it is advisable to give priority to the selection of engineering excavation materials as the source of concrete aggregates, and then analyze the amount of materials available for engineering excavation, and use other material sources to supplement the shortage.
(3) Concrete aggregate sources planning

The total amount of excavation of the main body of the project and the temporary construction project is about 4.26 million m³, and the amount of boulders in the overburden excavation is about 450,000 m³. Through preliminary analysis, excluding strongly weathered rock masses, faults and fracture zones (total amount is about 1.025 million m³), the total amount of geological usable rock is about 3.685 million m³, accounting for 78% of the total excavation. The available amount of excavation materials for the project is shown in Table 1.

Table 1. The available amount of excavation materials

| Location          | Excavation (ten thousand m³) | Available amount (ten thousand m³) | Utilization rate (%) |
|-------------------|------------------------------|------------------------------------|----------------------|
| Diversion project | Open cut 36                  | Cave digging 18                     | 50                   |
| Left bank of      | Open cut 76                  | Cave digging 40                     | 53                   |
| abutment slope    |                              |                                    |                      |
| Right bank of     | Open cut 110                 | Cave digging 90                     | 82                   |
| plant and dam     |                              |                                    |                      |
| Plant and dam     | Open cut 4                   | Cave digging 3.6                    | 90                   |
| foundation        |                              |                                    |                      |
| Traffic Engineering| Open cut 20                  | Cave digging 12                     | 60                   |
| Other             | Solitary stone 45            |                                    | 89                   |
| Total             | 471                          | 368.5                              | 78                   |

It can be seen that among the materials available for excavation in the project, the excavation material that meets the requirements of concrete aggregate is about 3.685 million m³, which is greater than the design requirement of concrete aggregate 3.2 million m³, and theoretically meets the conditions of no new opening yard. However, it is also necessary to resolve key issues such as the improvement of excavation material management, the improvement of aggregate processing technology, and the conflict between filling materials and aggregate utilization caused by increasing the utilization rate of materials from about 60% to 78%.

4. Earthwork balance planning

It is necessary to plan the excavation material and balanced utilization plan in terms of time and space according to the construction schedule and general construction layout plan in earthwork balance planning, and coordinate the contradiction between concrete aggregate and filling material in the use of engineering excavation materials which can reduce the turnover and loss of available materials.

According to the construction time of each part of the project, the quality of the excavated materials, the storage conditions, the earthwork balance planning for the excavated materials is shown in Table 2.

Table 2. Excavation material balance planning

| Location          | Excavation (ten thousand m³) | Aggregate utilization | Engineering filling utilization | Site filling utilization |
|-------------------|------------------------------|------------------------|-------------------------------|--------------------------|
| Temporary works   | Earth excavation 7           | 35.5                   | 7                             | 39                       |
| Traffic           | Stone excavation 110         |                        | 35.5                          | 7.5                      |
| Engineering       | Earth excavation 15          | 48                     | 7.5                           | 12                       |
| structural work   | Stone excavation 60          |                        | 63                            | 112                      |
| total             | Earth excavation 175         |                        |                               |                          |
|                   | Stone excavation 256         |                        |                               |                          |
|                   | total 623                    | 320                    | 125                           | 178                      |

Note: The engineering quantities in this table are all natural squares.
From the overall balance planning of the excavation materials and the flexible planning of the site filling materials, under ideal conditions, all kinds of materials have sources that meet the quality and quantity requirements, which can realize the project without mining yards and no permanent disposal. However, the waste of excavation materials and pollution caused by geological, construction and management reasons may appear during the implementation process, which may cause material shortages, especially for concrete aggregate sources. In addition, changes in engineering quantities may also occur, which can affect the state of balance. Therefore, in the process of planning and implementation of earthwork balance, a series of backup measures need to be taken:

(1) According to the construction diversion plan, the cofferdam can be dismantled in advance when the dam has not been poured to the top, and this part of the dismantled material will be used as a backup source of concrete aggregate for the later stage of the main project. Therefore, during the planning, design and filling construction of the cofferdam, strict requirements are imposed on the filling material of the upper part of the cofferdam.

(2) The project does not set up permanent waste slag yard. Reserve a site with a larger elastic space for filling materials as the construction site for the later stage of the project, and determine the filling amount and filling height of the site according to the actual implementation; in addition, the cofferdam demolition material is discarded below the dead water level of the reservoir area.

5. Conclusion
The fine balance planning of open excavation material is achieved through the green source planning, and the precedent of no mining material yard and no permanent waste slag yard for large-scale hydropower generation in ecologically fragile plateau area is realized. The planning protects the environment and Saves engineering investment effectively. The planning which has important social significance and economic value can provide reference for other similar engineering designs.

References
[1] General Office of the State Council. Guiding Opinions of the General Office of the State Council on Promoting the Stable Growth of the Building Materials Industry, Adjusting the Structure and Increasing Benefits [Z].2016-5-18.
[2] Sha-sha Chen, Li-jun Li, Jian zhong zhou. Visualization technology in the application and research conditions balance system [J]. The people of the Yangtze river, 2004, 05.
[3] Xiao qiang wang. The construction of the field leveling [J]. Science and education wenhui , 2009, 05.
[4] Zhengrong Jiang. Site earthwork quantity calculation [J]. Construction workers, 1994, 05.
[5] Qiong-fang liu. Natural arch level 1 hydropower station conditions balance planning and implementation [J]. Yunnan hydropower, 2001, 02.