ENVIRONMENT IMPACT EVALUATION OF A NEW TYPE CONTINUOUS MIXING PLANT FOR DAM CONSTRUCTION

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ABSTRACT**:** On concrete dam construction work, it is necessary to manufacture a large amount of concrete and CSG (Cemented Sand and Gravel). The manufacture plant of concrete and CSG is operated in very long term, therefore the effect of its environmental impact could be serious. In general, there are two types of manufacture plant on the process of manufacturing concrete or CSG. The one is batch type plant; its mixing process is not continuous and it is necessary to repeat the processes of measuring and mixing every batch. The other is continuous mixing plant; mixing process is completely continuous, at the same time, the measurement and supplement of materials are also carried out continuously. Since continuous mixing plant can manufacture a large amount of products at short time, continuous mixing plant is suitable for manufacture plant of concrete dam construction. But it is hard to control the quality of products, so batch type plant used to be adopted as the mixer of the manufacture plant. In recent years, the new continuous mixing plant which can control the quality of products accurately has developed and been put to practical use on several projects of concrete and CSG dam construction. The best feature of this plant is its energy saving effect. This plant is equipped with a static continuous mixer for mixing concrete or CSG. This mixer is set up in vertical direction, and then it is possible to mix materials with no electric power but only by gravity force. In this study, environmental impact due to manufacture concrete and CSG by conventional batch type plant and new continuous mixing plant are estimated and compared, and then the advantage of new continues mixing plant for environment is discussed.

KEYWORDS: environmental impact, energy saving, continuous mixing plant

1. INTRODUCTION

In present-day life, various kinds of industrial products are produced all over the world, and it causes to consume a large amount of natural resources and energy, and causes to discharge exhaust gas and industrial waste. Environmental assessment is very important in every field of industry, and many research and investigating works have been carried out. Life cycle assessment is a method of evaluating the environmental impact systematically and quantitatively in the entire life cycle of product and processes or activities. In the field of construction, this method of life cycle assessment is also applied to a system of environmental assessment, and is carried out actively. In project of dam construction, because dam construction project is very big in scale, the project of dam construction has great influences on water quality and natural environment of neighboring area.

On the concrete dam construction project, the manufacture plant of concrete and CSG is operated in very long term, and its environmental impact could be serious. From this point of view, environmental impacts due to operating manufacture plant of concrete and CSG on dam construction work is discussed in this research. And this research focuses only on the processes of manufacturing concrete and CSG. Energy consumption and grovel warming potential, i.e. CO_2 discharge, are took up as the factors of environmental impacts in this research, and its values are estimated for conventional batch mixing plant and continuous mixing plant. Then the advantage of new continues mixing plant for environment is discussed.

2. MTHODS FOR MANUFACTURING CONCRETE AND CSG ON DAM CONSTRUCTION WORK AND ITS EQUIPMENTS

On concrete dam construction work, it is necessary to manufacture a large amount of concrete. In general, the aggregate materials is mined from the near pit from construction site, and transported to the manufacture plant built in the construction site, and then concrete is manufactured in the manufacture plant, and transported and placed to bedding plain of dam construction. Because of its advantageous to economy and ecology, CSG "Cemented Sand and Gravel" is focused in resent years. CSG is one of cement stabilized material which is composed of aggregate, cement and water, and it is possible to use river sand and gravel or excavated materials which are possible to get easily from the place near the construction site as aggregate. The strength of CSG is not so high, but CSG has the advantage of economy and ecology. The method of manufacturing and placing CSG is similar to that of concrete. Fig.1 shows the flowchart of process of manufacturing concrete and CSG. This research focuses only on the processes of manufacturing concrete and CSG, and discusses only the effect of operating plant on environment as shown in fig.1. Specifically, the quantity of their electricity consumption and CO_2 discharge are estimated and discussed.

There are two types of manufacture plant for concrete and CSG. The one is batch mixing plant; its mixing process is not continuous, and it's necessary to repeat the processes of measuring and mixing every batch. The other is continuous mixing plant; every process of mixing, measurement and supplement are carried out continuously. The details and features of these plants will be discussed in detail in following sections.

2.1 Batch mixing plant

On the dam construction project, the batch type mixer, the processes of measuring and mixing is repeated every batch, is adopted as mixer of its mixing plant in general. The process of measuring and mixing of batch type mixer is conducted every batch, therefore it is possible to control the quality of the products certainly. But if it is necessary to product a large amount of concrete or CSG, the plant is necessary to be equipped with higher capacity mixer or several mixers. Therefore it should result in increase in equipment costs and operating costs.

2.2 Continues mixing plant

The other type of plant is continuous mixing plant. This type of plant conducts the processes of measuring and mixing continuously, and it can manufacture a large amount of products at short time, so it is suitable for manufacture plant of concrete dam construction. But previous continuous

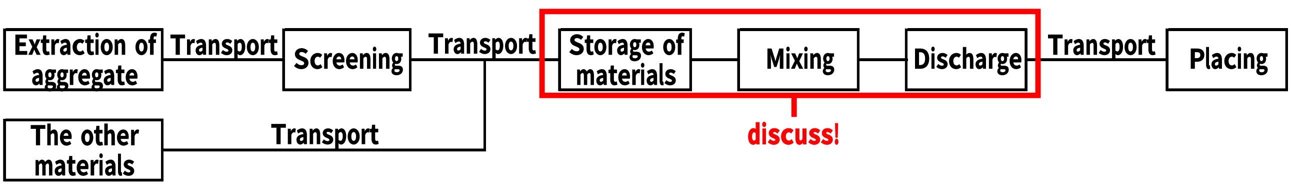

Fig.1 Flowchart of process of manufacturing concrete and CSG.

mixing plants were hard to control the quality of products, so batch type plant used to be adopted as the manufacture plant for concrete dam construction. In recent years, the new continuous mixing plant which can control the quality of products accurately has developed by Maeda et al. in Japan, and was put to practical use on several projects of concrete and CSG dam construction in Japan and China. Therefore our choice of manufacture plant became wider. Fig.2 shows the outline of new continuous mixing plant, this new continuous mixing plant is mainly composed of material feeders, belt conveyers, continuous mortal mixer and continuous concrete mixer. In this system, the supply condition of each constituents of concrete is shown Fig.2 and managed by real time monitoring system in real time when mixing. And a continuous static mixer, witch is called "MY-mixer", is adopted as concrete mixer. MY-mixer was developed by Maeda et al. The structure and mixing concept of MY-mixer is shown in Fig.3, it is composed of box shape units which have two vertically paralleled inlets and two horizontally paralleled outlets, and the units are connected in series. When materials get through every MY-mixer unit, materials are kneaded and lapped, as a result, two layers of materials at inlet increase by double of that to four layers (2^2=4). If n number of MY-mixer units is connected, the number of material layers after getting through MY-mixer is equal to 2^n, this principle is called 2^n mixing theory of MY-mixer. In case of mixing concrete or CSG, the MY-mixer is set up in vertical direction as Fig.2, and then it is possible to mix concrete without electric power but only by gravity force. Tek Raj Gyawali et al. conducted comparisons of this new continuous mixing plant and ordinary batch mixing plant for productivity and quality of concrete, and they concluded that this system has capacity of producing large quantity of concrete with its precise quality, and this system not only rationalizes the concrete production work, but also helps to protect the environmental condition by decreasing electric consumption in large scale.

3. ENVIRONMENTAL INPACT DUE TO MANU- FACTURING CONCRETE AND CSG

In this research, the environmental impacts due to manufacture concrete and CSG of dam construction in case of operating batch mixing plant

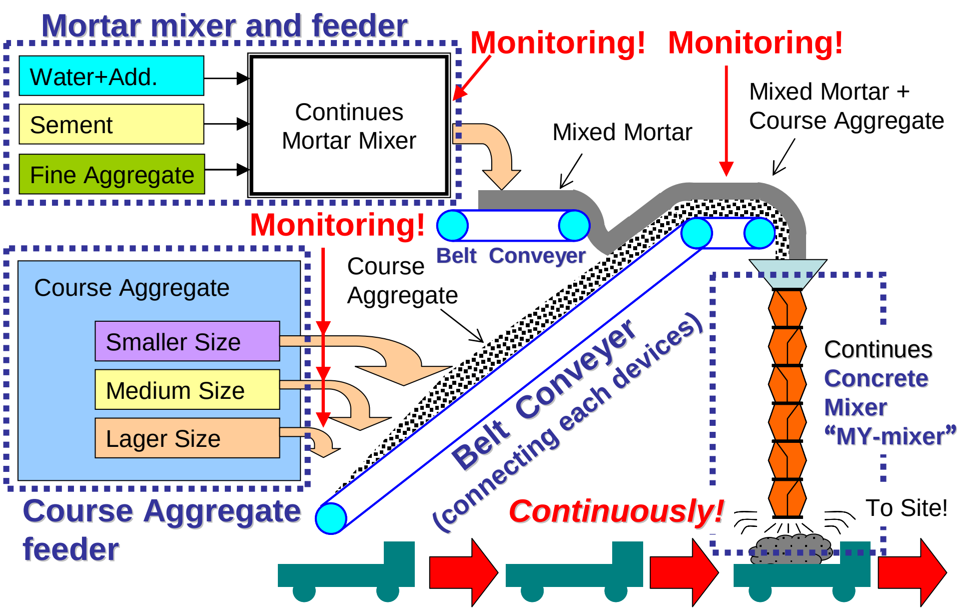

Fig.2 Outline of new continuous mixing plant.

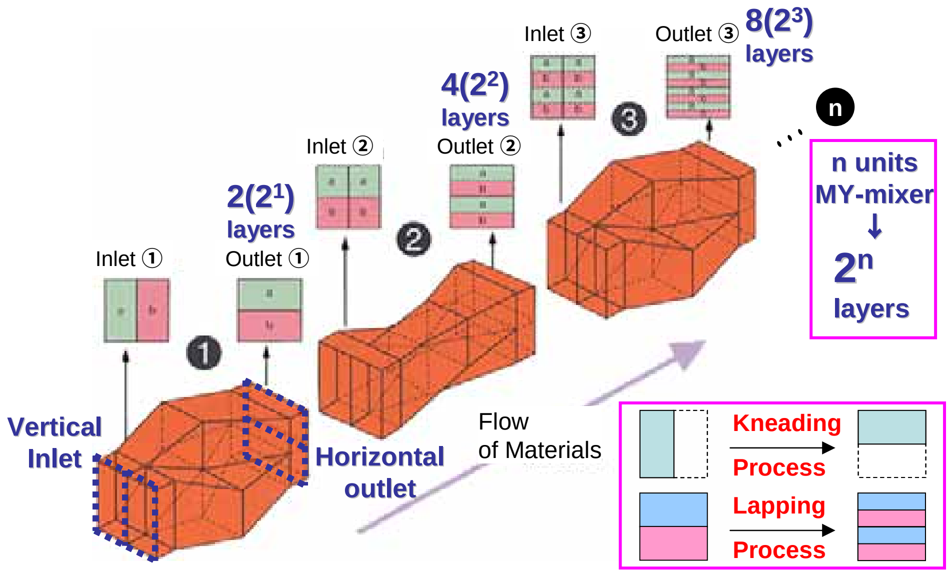

Fig.3 Continuous concrete mixer "MY-mixer" and its mixing theory.

and continuous mixing plant are estimated and discussed. In these estimations, electricity consumption and CO_2 discharge are calculated as environmental impacts. First the total electric power of each equipment, namely necessary power per hour (kW) for operating the plant, is calculated. And then calculated power divided by production capacity of the plant is power consumption per unit volume of product (kWh/m^3), and the power consumption multiplied by environmental impact rate of CO_2 (kg/kWh) is CO_2 discharge per unit volume of product (kg/m^3). In these calculations, the required power for each equipment is referred to reference 6. And environmental impact rate of CO_2 is defined as 0.371kg/kWh referred to the investigating result by concrete committee of Japan society of civil engineers (Reference 1).

4. ESTIMATION RESULTS

4.1 Concrete plant

Fig.4 shows the outline of batch mixing plant. This plant equips 2m^3 pug mill type forced mixer. Since it is necessary to mix dam concrete composed of large size particle of aggregate, the cycle time of mixing is set to 90 minutes, and thus its mixing capacity is 80m^3 per hour. On its manufacture processes, first the materials are transported to the main tower of plant by each feeder and belt conveyers, and then measuring of materials and mixing of concrete are conducted repeatedly. Fig.6 shows the outline of continues mixing plant. This plant equips a continuous mortar mixer and a continuous concrete mixer "MY-mixer". The capacity of continues mortar mixer is 70m^3/h and the capacity of MY-mixer is 150m^3/h. In its manufacture processes, first the course aggregate are fed to the belt conveyer 1 by each feeder continuously. At the same time, powder materials, fine aggregate and water are fed into continuous mortar mixer and mixed continuously, and then the mixed mortal is fed on the course aggregate on belt conveyer 1. And the all of materials on belt conveyer 1 are transported to the top of the MY-mixer and dropped into the inside of MY-mixer, and then concrete mixing is conducted continuously at the inside of MY-mixer only by gravity force. The details of structure and equipments of their two plants are given in table 1.

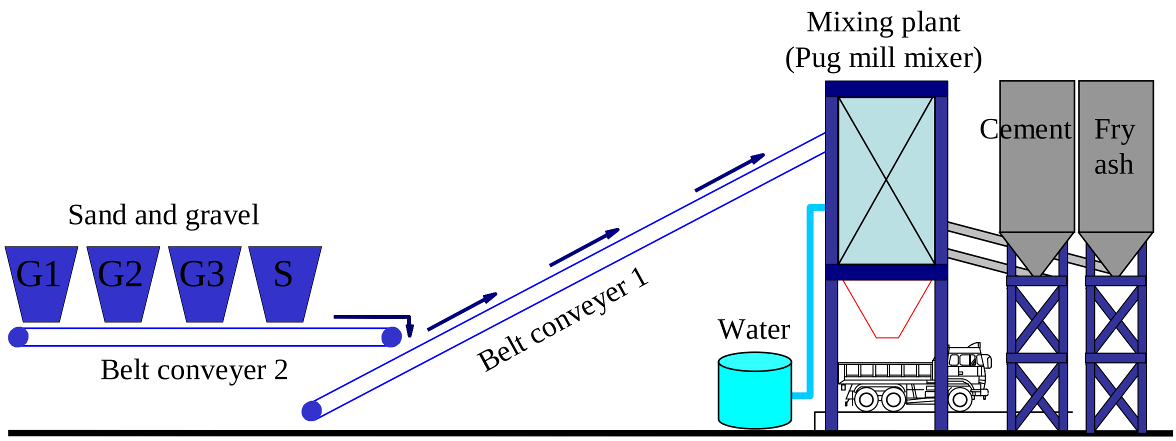

Fig.4 Outline of batch mixing plant for concrete.

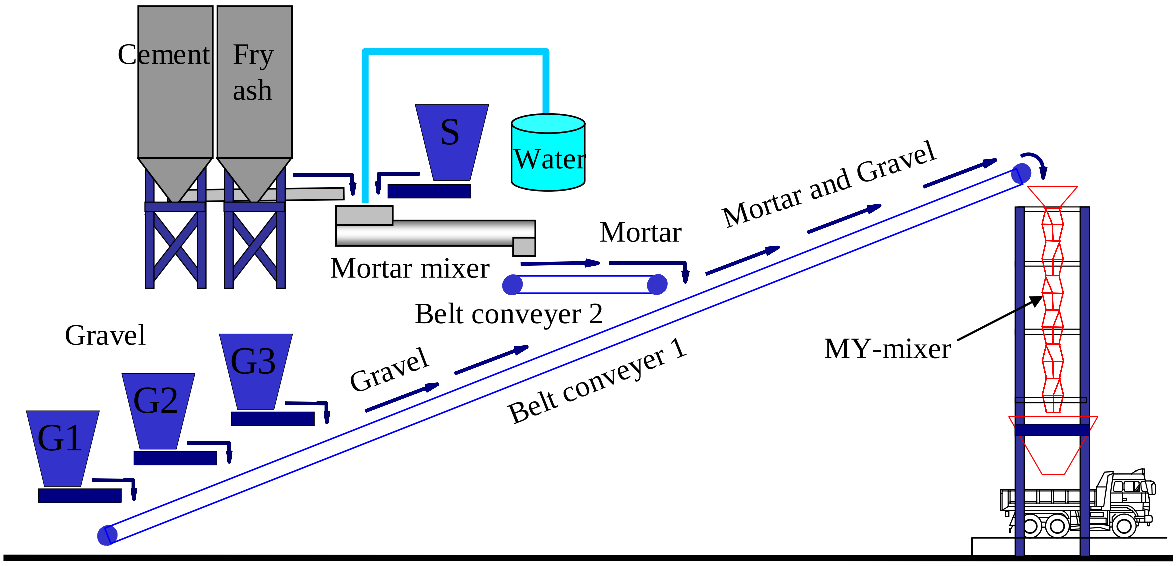

Fig.5 Outline of continuous mixing plant for concrete.

Table 1 Capacity and equipments of plant.

	Batch mixing plant	Continues mixing plant
Maximum production capacity	80 m^3/h	150 m^3/h
Equipment for material suppliment	belt conveyer-1 350t/h belt conveyer-2 180t/h cement feeder 12t/h water pomp 0.5m^3/min dust extractor 20m^3/min	belt conveyer-1 350t/h belt conveyer-2 180t/h belt feeder 120t/h ×4 cement feeder 12t/h water pomp 0.5m^3/min dust extractor 20m^3/min
Mixer	mixer 2.0m^3	Continues mortar mixer 70m^3/h MY-static mixer 650*650 L=6.5m
Notes	mixing cycle time 90s	

Table2 shows estimated results of power consumption and CO_2 emission of each plant for concrete. At the estimation of batch mixing plant, because its material supplement is not continuous, the duration of operating equipments for material supplement are considered as 30 minutes per hour (i.e. 0.5 times of all duration). For example, total primal electric consumption of belt conveyer is 35.5kW, and then it multiplied by 0.5, thus its electric consumption is equal to 17.8kW. As shown in table2, the total powers of two types of plants are almost same. However their maximum production capacity of continuous mixing plant is higher than that of batch mixing plant. Therefore the power consumption and CO_2 emission per unit volume of production concrete of continues mixing plant is less than that of batch mixing plant (i.e. batch mixing plant 1.47kWh/m^3, 0.544kg/m^3 and continuous mixing plant 0.80kWh/m^3, 0.299kg/m^3). The ratio of these values of continuous mixing plant to those of batch mixing plant is 54.9%. This may be concluded that continuous mixing plant is more environment-friendly than the conventional batch mixing plant.

4.2 CSG plant

Fig.6 shows the outline of batch mixing plant. This plant equips 3m^3 tilting type gravity mixer. Its cycle time of mixing is set to 180 minutes and its mixing capacity is 60m^3 per hour. In this plant, aggregates and cement are fed to belt conveyer 1 by each feeder and transported to the main tower of plant, at the same time water is pumped up to the main tower by water pump, and then measuring of materials and mixing of CSG are conducted repeatedly. Fig.7 shows the outline of continues mixing plant. This plant equips a continuous mixer "MY-mixer"; its capacity of mixing is 150m^3/h. In this plant, aggregates and cement are fed to the belt conveyer 1 continuously by each feeder, and they are transported to the top of the MY-mixer and dropped into the inside of MY-mixer. At the same time, water is continuously fed into inside of MY-mixer from holes which are set on the side wall of MY-mixer, and then mixing of CSG is conducted at the inside of MY-mixer continuously only by gravity force. The details of structure and equipments of their two plants are given in table 3.

Table 2 Estimated results of power consumption and CO_2 emission.

		Batch mixer plant		Continues mixer plant	
Maximum production capacity		80 m^3/h		150 m^3/h	
Electiric consumption		Equipment	Power	Equipment	Power
	Material supplement	belt conveyer	17.8 kW	belt conveyer	35.5 kW
		cement feeder	5.5 kW	belt feeder	18.0 kW
		fly ash feeder	5.5 kW	cement feeder	11.0 kW
		air compressor	7.5 kW	fly ash feeder	11.0 kW
		water pomp	2.3 kW	water pomp	4.5 kW
		dust extractor	3.7 kW	dust extractor	3.7 kW
	Mixer	concrete mixer	75.0 kW	mortar mixer	37.0 kW
				concrete mixer	0.0 kW
	Total power	117.2 kW		120.7 kW	
Power consumption per m^3		1.47 kWh/m^3		0.80 kWh/m^3	
CO_2 emission per m^3		0.544 kg/m^3		0.299 kg/m^3	

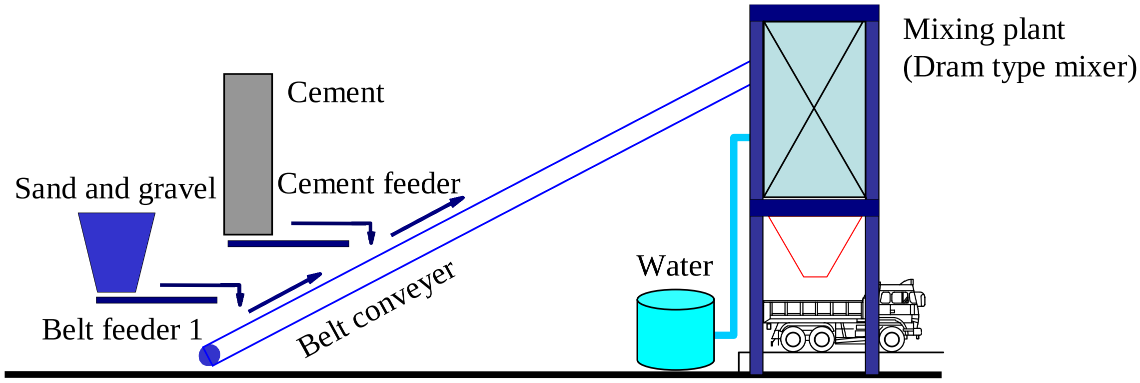

Fig.6 Outline of batch mixing plant for CSG.

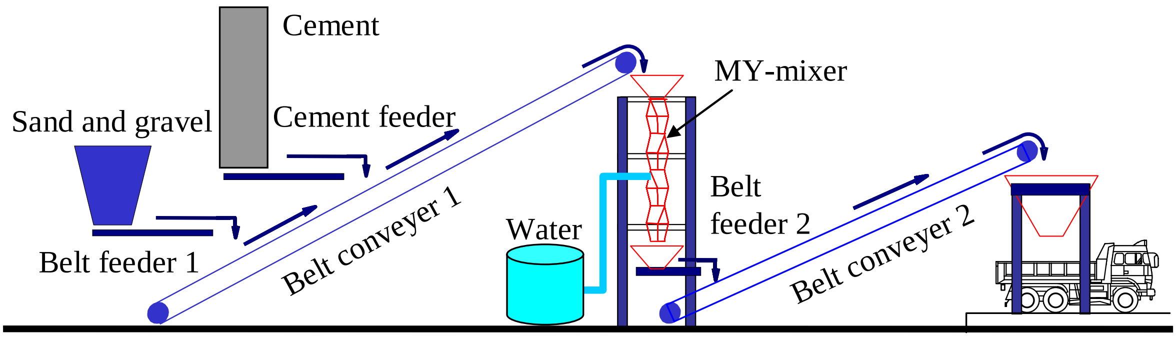

Fig.7 Outline of continuous mixing plant for CSG.

Table 3 Capacity and equipments of plant.

	Batch mixing plant	Continues mixing plant
Maximum production capacity	60 m^3/h	150 m^3/h
Equipment for material suppliment	belt conveyer 350t/h cement feeder 12t/h belt feeder 350t/h water pomp 0.5m^3/min dust extractor 20m^3/min	belt conveyer-1 350t/h belt conveyer-2 350t/h belt feeder-1 350t/h belt feeder-2 350t/h cement feeder 12t/h water pomp 0.5m^3/min dust extractor 20m^3/min
Mixer	dram type mixer 3.0m^3	MY-static mixer 650*650 L=5.2m
Notes	mixing cycle time 180s	

Table 4 shows estimated results of power consumption and CO_2 emission of each plant for CSG. At the estimation of the electric consumption of batch mixing plant, because its material supplement is not continuous, the duration of operating equipments for material supplement are considered as 24 minutes per hour (i.e. 0.4 times of all duration). For example, total primal electric consumption of belt conveyer is 30kW, and then it multiplied by 0.4, thus it is equal to 12kW. As shown in table 4, the total powers of two types of plants are almost same. However their maximum production capacity of continuous mixing plant is higher than that of batch mixing plant. Therefore the power consumption and CO_2 emission per unit volume of production concrete of continues mixing plant is less than that of batch mixing plant (i.e. batch mixing plant 1.05kWh/m^3, 0.388kg/m^3 and continuous mixing plant 0.43kWh/m^3, 0.158kg/m^3). The ratio of these values of continuous mixing plant to those of batch mixing plant is 54.9%. This may be concluded that continuous mixing plant is more environment-friendly than the conventional batch mixing plant.

5. Conclusion

In this research, the environmental impact due to operating mixing plant of concrete and CSG in dam construction project was estimated for conventional batch mixing plant and new continuous mixing plant. In both situation of manufacturing concrete and CSG, the estimated power consumption and CO_2 emission of continuous mixing plant are less than that of batch mixing plant. As a result, continuous mixing plant is more environment-friendly than the conventional batch mixing plant.

Table 4 Estimated results of power consumption and CO_2 emission.

		Batch mixer plant		Continues mixer plant	
Maximum production capacity		60 m^3/h		150 m^3/h	
Electiric consumption		Equipment	Power	Equipment	Power
	Material supplement	belt conveyer	12.0 kW	belt conveyer	44.0 kW
		belt feeder	2.2 kW	belt feeder	11.0 kW
		cement feeder	0.9 kW	cement feeder	2.2 kW
		water pomp	1.8 kW	water pomp	4.5 kW
		dust extractor	0.9 kW	dust extractor	2.2 kW
	Mixer	drum type mixer	45.0 kW	MY-mixer	0.0 kW
	Total power	62.8 kW		63.9 kW	
Power consumption per m^3		1.05 kWh/m^3		0.43 kWh/m^3	
CO_2 emission per m^3		0.388 kg/m^3		0.158 kg/m^3	

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