Journal of Nepal Geological Society, 2000, Vol. 22, pp. 31–34

Aggregate and environment

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ABSTRACT

The problem of aggregate and environment concerns the whole aggregate production comprising quarrying, crushing, sieving, transporting, and waste management. The most important primary environmental impacts are the influences on groundwater and the deterioration of the scenery. The secondary impacts include problems of aggregate production and land use planning near the quarries and crushing plants. Means to minimise primary environmental impacts include the change of raw material balance from the use of loose deposits instead of bedrock and the increase in reuse and recycling of aggregates. Determination of hydrogeological constraints and rehabilitation plans for land restitution help to exploit natural resources by taking into account the later use of the land surface for other purposes.

INTRODUCTION

Aggregate comprises pieces detached from bedrock or larger boulders either by a natural process or an artificial method. People living in modern society demand the use of aggregate in one or another form (Ihalainen 1996). For instance, in Finland the average annual consumption of aggregate is about 15 tons per capita. About 50 % of the aggregate is needed for construction of roads and streets, 5 % for asphalt pavements, 10 % for concrete, and 35 % for other purposes (Fig. 1).

For the production and consumption of aggregate, some principal regional factors such as general geological conditions, climate, stage of the society's development, and maturity of the infrastructure must be considered. The problems caused by aggregate production thus vary from region to region. When dealing with the problems of aggregate and environment, the whole aggregate production chain must be considered. It comprises quarrying, crushing, sieving, transport, and waste management. The production of aggregate causes primary and secondary impacts to the environment. The primary impacts are mainly related to quarrying and processing of aggregate. The secondary impacts adversely influence the cyclic system of biotic as well as abiotic environment.

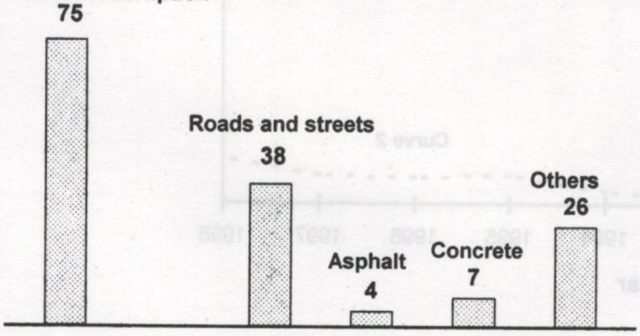

Fig. 1: Annual consumption (in millions tons) of aggregate in Finland for various purposes

PRIMARY IMPACTS

The impacts on groundwater are chemical, physical, or functional. Chemical changes of groundwater near a quarry are rather common. These changes can be caused, for example, by explosives or by oil leakages from the production machinery. In many cases, the bedrock fracture systems are able to lead very rapidly the groundwater pollutants far away from the quarry site. One of the most evident physical changes is the fluctuation (mainly lowering) of water table. The heaviest primary impacts occur if some functional changes to the biosphere are caused. For example, if gravel is exploited to the level beneath the water table, the natural barrier between the biotic and abiotic ecosystems is breached.

When quarrying in a certain area, the natural ground surface is lost for ever. The quarry site will loose its original character and severe damage is also caused to its immediate surroundings. The change of scenery is irreversible. However, the worldwide rock resources are vast and the usable volume of bedrock can be considered to be unconfined. Principally this is true, but in practice it is not possible to quarry the earth's crust as a whole and heap the quarried material to some other place. Instead, the use of fluvial, glaciofluvial, and alluvial deposits destroys these geological formations for a very long time which can be considered as lost for ever in human point of view. On the other hand, the total volume of gravel is so small that in practice the use of gravel resources should be strictly limited.

In certain areas, high quality aggregate can be dredged from the submarine deposits. Often the dredging causes serious changes in coastal forces and submarine streams. The consequences of an intensive dredging may include great variations in both the coastal erosion and sedimentation.

Also, the disadvantages in producing aggregate play a certain role among the other environmental impacts. Things like noise, dust, and vibrations are caused when digging, drilling, blasting, and crushing the rock materials. These acute disadvantages lead to serious problems, especially in urban and other densely inhabited areas.

SECONDARY IMPACTS

One important problem connected with aggregate production is the long-term land use planning near the quarries and aggregate factories (crushing plants). It is not possible to place modern society's activities close to the functioning or rejected quarrying areas.

If the aggregates are produced in densely populated areas, the local traffic and its emissions form a serious environmental problem. In some cases also the road areas themselves can be considered as problematical. In mountainous areas, the road construction itself is able to trigger dangerous processes like landslides. The production chain of aggregates also affects the worldwide logistics. In environmental point of view, it is not same if the aggregates are transported for example by lorries or by boats. The latter means of transportation is more environment-friendly, although the lack of return cargo, for example, may often make it less profitable. Aggregate materials belong to high-bulk, low-value deposits. Because of high transportation costs, they cannot be shipped to great distances. Beyond a certain distance, the transportation costs exceed those of the raw commodity. This tends to increase the number of quarries and pits around urban areas.

Environmental impacts of the industry that produces the machinery and equipment for the aggregate production can be unimaginably wide. The emissions of the metal industry are high, and we must keep in mind that every industrial operation produces some waste.

Surficial deposits, regoliths, weathered parts of bedrock, and the like must be removed before quarrying the aggregate. The problems of heaping this removed waste are encountered, especially in many urban areas and large road construction sites. Even though the volume of the removed materials is remarkably smaller than the volume of the used aggregate, the trends of changes in volumes are alike. Today's legislation concerning the wastes has remarkably decreased the volume of the heaped waste materials. Instead of heaping, these materials are planned to be reused as much as possible. Fig. 2 shows the consumption of rock aggregate in Finland during the last 14 years and the amount of waste earth material resulted from different construction works in a large suburban area around the city of Helsinki. Fig. 3 depicts the annual use of aggregate in Finland and the use of crushed rock aggregate during the same period.

The changes of microclimate in and around the quarries should not be underestimated. In many cases, the type and amount of vegetation as well as fauna are changed because of quarrying. These changes may also have some additional impacts, for instance in groundwater table and groundwater quality.

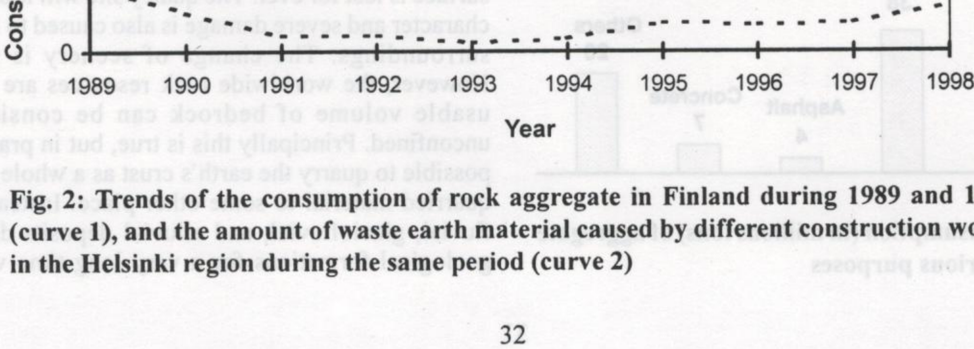

Fig. 2: Trends of the consumption of rock aggregate in Finland during 1989 and 1998 (curve 1), and the amount of waste earth material caused by different construction works in the Helsinki region during the same period (curve 2)

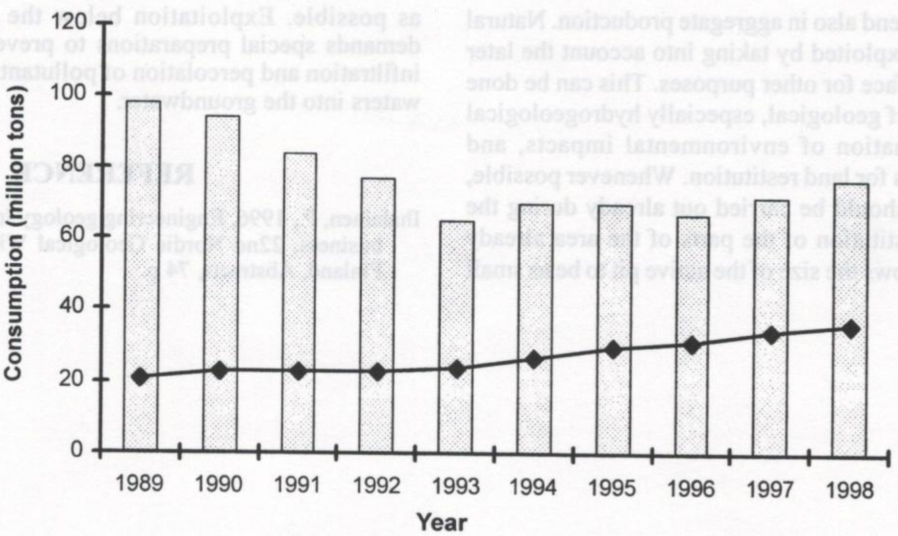

Fig. 3: Annual consumption of aggregate in Finland (columns) and the use of crushed rock aggregate (curve) during the same period

Locally, the pits that are no more in use form a remarkable environmental problem. Especially the bedrock pits, either empty or full of groundwater are dangerous both for animals and people. However, the gravel pits are rather easy to be protected from accidents after the use, e.g. by fencing the old pit and making the slopes gentler.

SOLUTIONS TO THE PROBLEMS

A means of minimising the primary environmental impacts is to change the raw material balance from the use of loose deposits towards the use of bedrock. Bedrock aggregates can also be produced by underground mining. In human point of view, the bedrock resources are unconfined but the quality of available bedrock can be a problem. There are certain types of aggregate, which are very difficult to replace by using crushed material instead of well rounded fluvial material. This especially concerns the concrete industry.

Today, the reuse of aggregate plays an important role, especially in densely inhabited areas. Serious problems can be faced in recycling if some polluted materials come in process. However, a great deal of the waste soil material is unusable for recycling due to its grain size and consistency. Crushed concrete is very usable for recycling, but still the price stays high as compared with the price of virgin materials. Also, the old bituminous pavements are convenient for recycling. A factor helping the economy of pavement recycling is the expensiveness of bitumen. As the transportation contributes greatly to the aggregate price, even the worst quality of crushed rock may often be used in urban areas.

The principle of sustainable development can be applied also to the aggregate production. The aggregate has its typical life cycle which can be analysed. We must also think about the ethical things and ask ourselves if our generation has the right to dig away all the glaciofluvial eskers and alluvial fans. The cost of various components of nature like scenery, vegetation, or even silence is not easy to evaluate. What is the price of the non-measurably things that suffer from aggregate exploitation? Does the aggregate production give more than it takes? How to share the surplus? What is the role of geologists in solving these questions?

Environmental Impact Assessment (EIA) has somewhat helped the understanding as well as processing many environmental problems connected with aggregate production. In best cases, EIA gives really new data and information for the decision-makers as well as for the aggregate producer himself.

CONCLUSIONS

It seems that there is no very clear single individual idea to solve the problems. The local circumstances must be taken in account and every case seems to be different from the others. One good method of avoiding the environmental destruction is to observe how the things are carried out in other comparable quarries. It is also useful to learn from the mistakes made by others. To push the problems to the near future, with the idea that the increase of economic activity solves them, seems not to be a good method to support the sustainable development.

Like in the production of metals and industrial minerals, adoption of guidelines of sequential land use after extraction will be the future trend also in aggregate production. Natural resources can be exploited by taking into account the later use of the land surface for other purposes. This can be done by determination of geological, especially hydrogeological constraints, evaluation of environmental impacts, and rehabilitation plans for land restitution. Whenever possible, the rehabilitation should be carried out already during the exploitation by restitution of the parts of the area already harvested. This allows the size of the active pit to be as small as possible. Exploitation below the groundwater level demands special preparations to prevent or minimise the infiltration and percolation of pollutants through the runoff waters into the groundwater.

REFERENCE

Ihalainen, P., 1996, Engineering geology in Finland – science or business. 22nd Nordic Geological Winter Meeting. Turku, Finland, Abstracts, 74 p.