Application of the Crystallographic tiling to Increase Competitiveness of the Sand Sediments

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Abstract. Mount Merapi eruption in 2010 resulted in the environmental damage and disruption of socio-economic life of the society. Post-eruption cold lava floods carry the volcanic sedimentary materials in the form of sand and stone are very abundant. Unfortunately, the abundance of these natural resources is exploited at low prices. The problem is how to manage the sedimentation to have high economic value. The adaptation efforts to manage this sediment need to be done to immediately restore the social economic slump of society. The sediment management model that can improve economic value and competitiveness needs to be done by maintaining the sustainability of its natural resources. This article contains the results of research on the application of crystallographic tiling to improve the economic value and competitiveness of sand sediments. Three types of sediment-based products are successfully made of tiles, rosters, and paving.

1. Introduction
The Mount Merapi eruption in 2010 has brought environmental disaster and disaster for the surrounding community. Cold lava flows after eruption have damaged water catchments and river basins with abundant volcanic sediments in the form of sand and stone. The abiotic and biotic environment suffered severe damage, which had an impact on the socio-economic, health and psychological deterioration of the community. Volcanic sediments have closed approximately 27 km\textsuperscript{2} in the catchment area of Gendol-Opak [1]. The sediment load fluctuates along lava flows [2]. The impact of the 2010 eruption on public health and the economy, even on the aviation world has been widely discussed in volcanology articles [3]. The eruption has a broad impact on social change [4], essential infrastructure [5], as well as on psychosocial and environmental disorders [6]. These conditions cause an impact on socio-economic vulnerability [7]. The environmental damage can increase unemployment. Increasing the capacity of society adaptation after the eruption of Mount Merapi is carried out in the context of the recovery of the socio-economic society, psychological and physical health, and the recovery and rehabilitation of the environment. Efforts to restore socio-economic conditions can be done by optimizing the potential of natural resources through the development of horticultural agribusiness [8]. Efforts in the education sector are carried out through disaster prevention learning in elementary school [9]. Psychological recovery by the hope intervention can reduce the level of society depression [10]. Adaptation to settlement relocation by skills training on tourism, so that women can work in tourism [11]. A measurable and adequate
evacuation system, and policy to prevent catastrophic eruptions in the greater future requires an effective early warning system. [12]

Very abundant high-quality sand sediments as presented in Figure 1, are only used for sale as building materials at low prices, so there needs to be an effort to increase the economic value of the sand. This article presents the results of research on crystallographic tiling that can be applied to improve the competitiveness and economic value of products based on volcanic sediments, that is tiles, rosters and pavings [13]. Increasing the community's expertise in crystallographic tiling through training will open up new employment opportunities, thereby reducing unemployment.

Figure 1. Abundant sediment

This article discusses applications of the crystallographic tiling to improve the competitiveness of tile, roster and paving products, whose its basic material is sand. Application of the crystallographic tiling to produce the tile, roster and paving that are different from existing products. This is a new method in the production process of tiles, roster, and paving.

2. Method
The technology application of the crystallographic tiling is based on group symmetry in the basic motif design of tile, roster and paving. The superiority and uniqueness of this product is from one basic motif can be arranged repeatedly to produce a structured pattern diagram. The steps taken are:

1) Make basic motif design of tile, roster, and paving. The basic motif is designed with respect to the crystallographic operator, that is a reflection, a translation, a rotation, and a glide-reflection. Figure 2 presents a basic motif design of tiles, a basic motif design of roster, and a basic motif design of paving.

Figure 2. The basic motif design of tiles, roster, and paving

2) Make mold of tile, roster, and paving.
3) Make prototype product of the tile, roster, and paving at the produsen by following the existing production process of tile, roster, paving. Figure 4 presents a prototype product of the tile, the roster, and the paving. These products are called the crystallographic tile, the crystallographic roster, and the crystallographic paving, respectively.

4) Simulation of setup by operating the crystallographic operators and their combinations. Figure 5 presents two arrangement patterns as examples.

3. Results and Discussion
The tile, roster and paving prototypes presented in Figure 4 are the results of the application of crystallographic tiling. The basic motif designed by considering the operation of the crystallographic operator provide added value to the product. These products can be arranged repeatedly can produce many new patterns. Based on the crystallographic theory [13], this innovation has resulted the excellence of this product when compared to similar products currently on the market.
The molds in Figure 3 was made of expensive steel, but by applying the crystallography theory in designing basic motifs, making these costs inexpensive. It was different with pre-existing mold, so innovation of this mold can decrease production costs. Since the users have many choices of patterns, then innovation basic motif design will enhance the competitiveness of products in the market. This innovation enhances the economic value of sand sediments higher than previous tile, roster, and paving products. The sand sediments carried by cold lava floods after the eruption are not exploited in the form of basic materials, but are developed into finished products that have a higher economic value.

This abundant natural resource management model with such product innovation is a form of implementation of the concept of sustainable development. Economic interests that demand high incomes can be met by increasing the economic value of its products rather than exploiting its natural resources.

4. Conclusion

The implementation of the three pillars in sustainable development requires technological innovation to achieve economic interests, which in parallel will maintain the sustainability of its natural resources. This innovative technology is one example to change the volcanic sediment that was originally perceived as a disaster to be a blessing for the welfare of today's society. The synergy of all stakeholders are needed to achieve high economic growth, but still pay attention to the sustainability of its natural resources.

Application of the crystallographic tiling to produce tiles can reduce the cost production because some various patterns can be produced by just one mold. Therefore, the resulting product has added value and competitiveness in the market. Likewise, the production of roster only requires one mold to produce many variations of the arrangement pattern. Increased competitiveness of paving products by providing crystallographic ornament motifs, so that it can produce many variations of arrangement patterns.

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