CONCERNS ON USING COAL SPOIL DUMPS (COLLIERY SPOILS) AS SUB-STANDARD MATERIALS FOR CONSTRUCTION MATERIALS

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RINGKASAN

Meningkatnya pembangunan sektor infrastruktur karena permintaan kebutuhan berimbas pada kenaikan biaya konstruksi serta berkaitan erat dengan penggunaan material standar yang juga cenderung menjadi mahal dan ini akan berlangsung terus pada masa mendatang. Penggunaan material sub-standar sebagai pengganti keberadaan material standar saat ini sangat di rekomendasikan sebagai penyelesaian meskipun tidak dapat di uji dengan metode test yang telah dikenal karena umumnya memberikan hasil yang berbeda-beda karena mengalami perubahan perilaku di lapangan. Penggunaan material sub-standar sedang gencar disarankan sehubungan dengan peraturan untuk menjaga kesimbangan lingkungan, dengan demikian penggunaan material standar yang umumnya digunakan sudah dibatasi. Selanjutnya, untuk menjaga kualitas lingkungan, seperti kontaminasi lahan, beberapa Pemerintah dari beberapa Negara telah pula menyarankan agar menggunakan material sub-standar (material local) meskipun akan mengalami perubahan karakteristik baik fisik maupun kimia karena kontak dengan bahan lain seperti teroksidasi dengan udara atau kontak dengan air. Limbah Batubara yang masih segar atau belum terkontaminasi dengan bahan lain sebagai material sub-standar lebih sering dijumpai dari pada yang sudah terkontaminasi dapat digunakan sebagai material konstruksi seperti 'bahan timbunan', 'lapis pondasi bawah' dan 'lapis pondasi atas' pada konstruksi pekerjaan jalan setelah beberapa rekomendasi penggunaannya dipertimbangkan seperti membuang dan melindungi atau meningkatkan material yang mudah terkontaminasi, meningkatkan ketahanannya dengan pemanasan temperatur tertentu pada material yang belum terkontaminasi untuk memperoleh material dengan kualitas baik, melakukan pengujian terhadap tingkat pencemaran serta mengkaji secara ekonomi untuk mendapatkan gambaran biaya produksinya bila digunakan sebagai material konstruksi.

Kata kunci : Bahan sub - standar, Produk industri dan buatan manusia, Limbah batu bara, Bahan bangunan dan solusi pemanfaatan.

SUMMARY

The developing infrastructure sectors are increased as a result that there have been increasingly demands for the use of Standard Materials and influenced the increasing construction costs and has been predicted to increase still future. The use of Sub-standard Materials to replace the Occurrence of Standard Materials is now being strongly recommended as a solution however there is Any Test Guides do not deal appropriate to them due to indicate the different results due to an experiencing behaviour of the actual field performance. The use of sub-standard materials are being encouraged due to the regulation on maintaining the environmental balance, so therefore, the use of suitable standard materials have been limited. Further, the uses of sub-standard materials (local materials) have been also urged by the government body or any country, who are aware and responsible to the damages or changes of the environmental balance caused by land contaminations however may commonly susceptible to changes on their characteristic either in chemically or physically as a result of reacting processes when they contact with other mineral substances, such as water and air. The 'unburnt spoils' (minestone) as sub-standard materials are most found rather 'burnt spoils' and can be used as material contractions such as 'fill materials', 'road base' and 'sub-base' of materials in road constructions after the following recommendations, such as removing or protecting and treating the spoil dump heap to prevent the ground water pollutions, upgrading using thermal treatment towards basic materials for producing the quality of construction materials, investigating the occurrences of the potential leachability and economic calculations to get a brief overview of the Costs of Mineral Product (COMP) when used as material constructions.

Keywords : *Sub - standard materials, Industrial and man-made by product, Coal spoil disposals, Material constructions, Utilizing solution.*

INTRODUCTION

In order to over come the recently impact of an environmental damage due to the developed infrastructure frames, Government of Indonesia through out the Ministry of Public Works has planned the living space with the environmental concerns on building a number of the road networks by concerning to the easily moving and the nicely environmental, such as the healthy of settlement places. In facts, however has been planned but the building infrastructures still affected to the changes of an environmental balance and produced the decreasingly of the quality standard live as a result of that some restricted land use has changed their useability, i.e. in order to fulfilling the human being needs.

In many countries, an occurring crucially potential affected on forcing to deal with the use of standard materials decrease the healthy environments. Therefore, to minimize this problem, the clearly statement on maintaining the environmental balance to produce the healthy living has been advised by the Authority Councils, such as the Government Body etc, who are responsible on this situation. Hence, the government body has currently restricted on the use of standard materials, consciously as the consequences the use of sub-standard materials for replacement is urged.

Other cases are also currently coming out to deal with on the use of standard materials may cause that those materials are becoming expensive and will influence the increasing construction costs. It is not surprisingly in anywhere that the availability standard materials is becoming limited or may have been prohibited on using them by an authority council due to affecting the environmental damages.

However, it has been reported by a number of authors that the problems on using the sub-standard materials can come out, such as the environmental land or air pollutions, but there is no choices on using them. Some sub-standard materials may shows commonly consist of a number of chemical substances, so therefore if those materials are used in construction works, will react with other mineral substances, such as water and air within the period of times, as part of the geological time scales, the materials can change on their characteristics in chemically then decreasing their strength.

Other research results also showed that the changes on chemically characteristics, can affect on accelerating the rate of weathering processes. It has been also proven by a number of researchers, for examples, the processes of weathering of rocks produced the new material types in different grades which are generally consist of six different grades of soil/rock decompositions. The grade one can be stated as a lower deposition consists of fresh rocks or un-weathered rocks. Then, the grade six can be stated as upper grade which has lain on the top or underneath the top soils and can be identified as completely weathered materials.

If the soil/rock types are developed from the deposited organic matters, such as spoils or dump materials of coal disposals or coal spoil dumps, may affect the environmental pollution problems due to changes their chemical characterization when those materials lay down expose to the air or contact with water. Then, those materials can affect to the environmental changes due to the large area become contaminated and within the period of time, can be often increasingly still further if those materials are letting lay down on their new deposited place for a long time.

The utilizing dump materials of coal disposals or coal spoil dumps used for an embankment construction may shows that those materials have changed their material characteristics due to they have been stockpiled for either temporarily or to deal with earthwork activities.

An Encouragement on Utilizing Sub-standard Materials as an Embankment Fills

In recent years, a parallel with the developing industrial sectors, the developing infrastructure sectors are increased as a result that there have been increasingly demands for the use of Standard Materials and influenced the increasing construction costs. For examples, in order to fulfill the needs of aggregates for road construction materials, during periods of 1960 to 1990, the annual production in the world has increased. In the UK for instance, the consumption of Standard Materials until recently has increased from 110 million to 300 million tonnes and has been predicted to increase still further, Sherwood (1994).

A similar case has occurred with the use of Standard Materials for fills, indeed, the amount of material for fills is usually greater than for aggregates because those materials are currently applied as an embankment of landfill for human settlement or road and dike construction building.

Referring from the availability of limited standard materials, hence the use of Sub-standard Materials to replace the Occurrence of Standard Materials is now being strongly recommended as a solution. Furthermore, the use of sub-standard materials will be also decreasing the construction costs and maintaining the environmental balance, Baldwin et al. (1999).

Unfortunately, however sub-standard Materials have been identified as their occurrence are being available in many areas, but their uses have been limited by either the user having a lack of knowledge or the expectation that those Materials will have a bad performance record. In order to minimize un uncertainty results on using sub-standard materials, the European Commission in the Community Strategy for Waste Management [COM 399], (1996), has urged and suggested on the use of sub-standard materials by minimizing the amount of waste production on fill reclamations. Examining the re–cycling and re–use of materials in earthwork activities and was also suggested, by which for use as much sub-standard materials as possible.

The problems on using sub-standard materials are that mostly International Standard Test Methods which have been established, such as British Standard (BS), ASTM and AASTHO and as well as many Standard Test Guides, they do not deal appropriately. Basically, all those standard tests have been based on experiences with Standard Materials in Temperate Zones, by using the Classical Soil Mechanics Approach, Terzaghi (1958), Newill (1961) and De Mello (1972). Therefore, the Standard Test Methods on above may be un-capable for determining the characteristics of Sub-standard Materials. Probably, those standard testing are giving the results that may indicate a different behaviour to the actual field performance.

To deal with the encouraging demand on using sub-standard materials, there are many references on exploring and investigating the useability of sub-standard materials used as replacing the standard materials, such as for fill materials in embankment construction buildings either for landfill or embankment for roads and dikes. The roughly figures on applying sub-standard materials in The Netherlands are shown in Figure 1.

The recommended results have been stated in many countries which are by modifying or applying these materials to specific requirements, however, until now there is no agreed method of specifying these materials have been disclaimed.

Type of Sub-standard Materials

They are two types of Sub-standard Materials can be recognized, they are any materials which are obtained from natural deposits and are obtained from man–made or industrial by products, Baldwin et al. (1999). Sub-standard materials which derived from geological process are named as natural deposits, whilst any materials derived from man–made materials are named for any materials derived from, either from industrial disposal by–products, mining wastes or similar resources. The natural deposits producing sub-standard materials may include the materials have been derived from the organic matters and have been deposited parallel within geological process periods.

Sub-standard Materials have been given different names such as Alternative Materials or Secondary Materials, Reid (1997).

Table 1.
Potential Product of Sub-standard Materials (J.J.M Heynena, H.N.J.A. Bolkb, G.J. Sendenc and P.J. Tummersd (1994)

Product	Application	Market potential in The Netherlands (tonnes/year)	Estimated revenue (Dfl. per tonne)
broken burnt-out minestone	- bulk-fill material	40,000,000	5 to 6
	- aggregate material for road-bases	8,000,000	7 to 8
	- supplementary materials for asphaltic concrete (warm production)	1,200,000 (gravel) 1,700,000 (split)	13 17 to 26
	- supplementary materials for cementous concrete	9,000,000	13 to 26
calcinated clay	brick industry	25,000 to 50,000	15 to 30
ceramic limestone (via end-production using calcinated clay)	construction industry	500,000*	80 to 100

*: based on 20% of the market volume of ordinary limestone and 75% replacement of primary raw materials by calcinated clay; ceramic limestone is a new product with improved properties.

Sub-standard Materials of Natural Deposit

The sub-standard materials came from natural deposit are shown in Figure 1, which is drawn that the materials can be divided into six (6) different grades. There are consists of grade one (1) stated as fresh rocks on the bottom levels then goes to the grade two (2), three (3), four (4), five (5) and finally grade six (6), which is occupying on the upper levels near to the surface, underneath of the top soils.

The different grades of the soil / rock stratigraphy are caused by the different level of weathering processes which is near to the surface, the weathering level is becoming high due to they are easily contaminating and reacting with the media such as water or air.

On Figure 1 is shown that accordance with McGown and Cook (1994), in general the weathered grade levels can be grouped as three (3) parts, which are CAP (Completely Altered Parent Materials), AP (Altered Parent Materials) and P (Parent Materials).

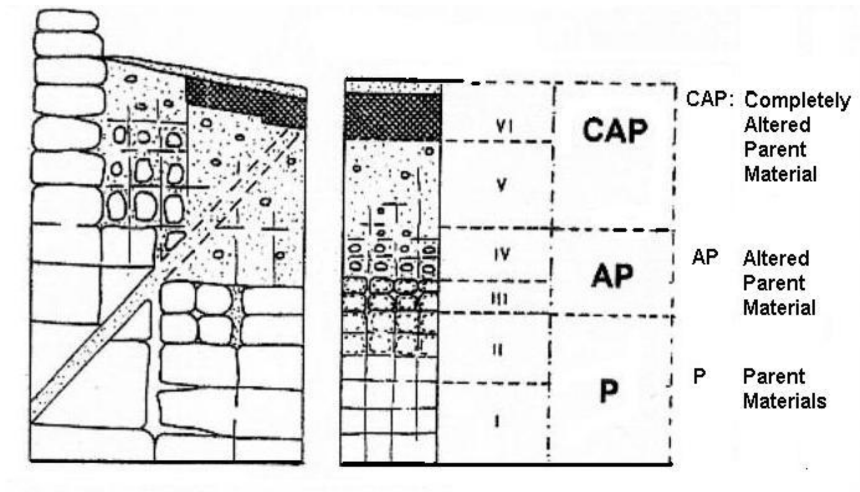

Figure 1. Horison of weathered grades of Soil / Rock Stratigraphy of Sedimentary and Volcanic Rocks (Millot, 1970 and MecGown & Cook, 1994)

The weathering processes existed due to Parent Materials (rock) during period of time as parts of geological times were experiencing with the change of their characteristics in chemically, Fitpatrick (1983) and showed as Figure 2.

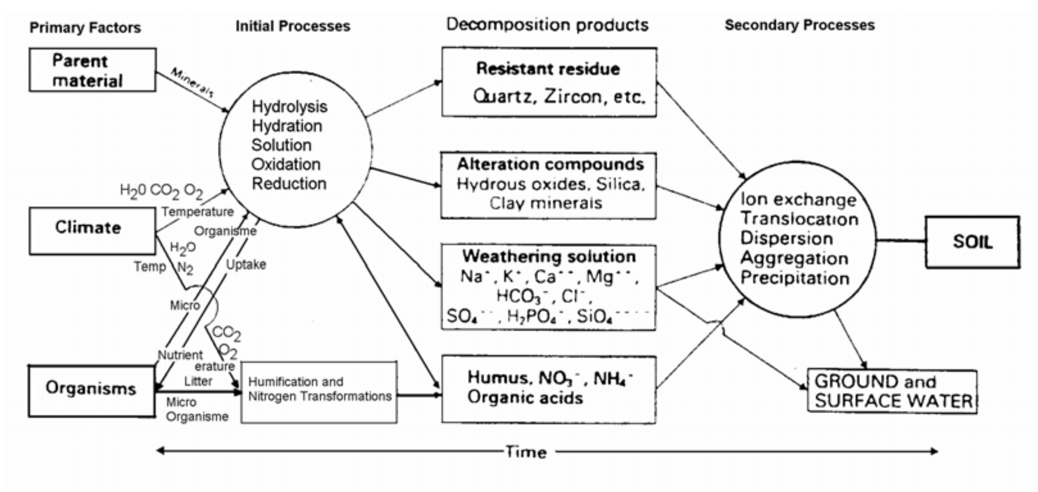

Figure 2. Chemical Weathering Processes (After Fitpatrick, 1983)

Sub-standard Materials of Man-made Products as Coal Spoil Dumps

It follows that, they are a number of Sub-standard Materials derived form man made products which are discovered in the world and some of the most of large scales of sub-standard materials is coal spoil dumps. An example, the coal spoil dumps came from the mining activities, such as in Netherlands that was carried out in 1975, leaving considerable amounts of coal spoil dumps in the direct environments of the former coal mining.

There are only a view part of coal spoil dumps heaps have been covered and integrated in the landscape, but large parts are still uncovered and not integrated, thus forming an obstacle in the landscape. Therefore, the important procedures to be carried out due to those materials are mostly affecting to the decreasing quality of the groundwater, which is threatened by these uncovered heaps, Goumans, at al (1994).

It was reported by Leach et al. (1991) that the coal spoil dumps which are commonly mixed with minestone, contains a considerable amount of pyrite (ironsulfides). The pyrite reacts with water or air can be oxidized to sulphuric acid. Then, in the field, the process of oxidation can be accelerated by thiobacilli bacteria as a catalyzation, especially at lower pH values. As a result of this biological catalyzation, the oxidation process can be speeded up, at pH-values below 2.5, by 105 - 106 times. Hence, therefore for the coal spoil dumps with contain enough lime, the sulphuric acid will be buffered, even when the lime buffer is exhausted.

The pH values in the percolate will drop (and boost accelerated biological oxidation) and form a threat for the groundwater quality as a result of acidification of the percolate. The contaminating adjacent land by the oxidization process producing sulphuric acids due to the pyrite reacts with water is shown on Figure 3.

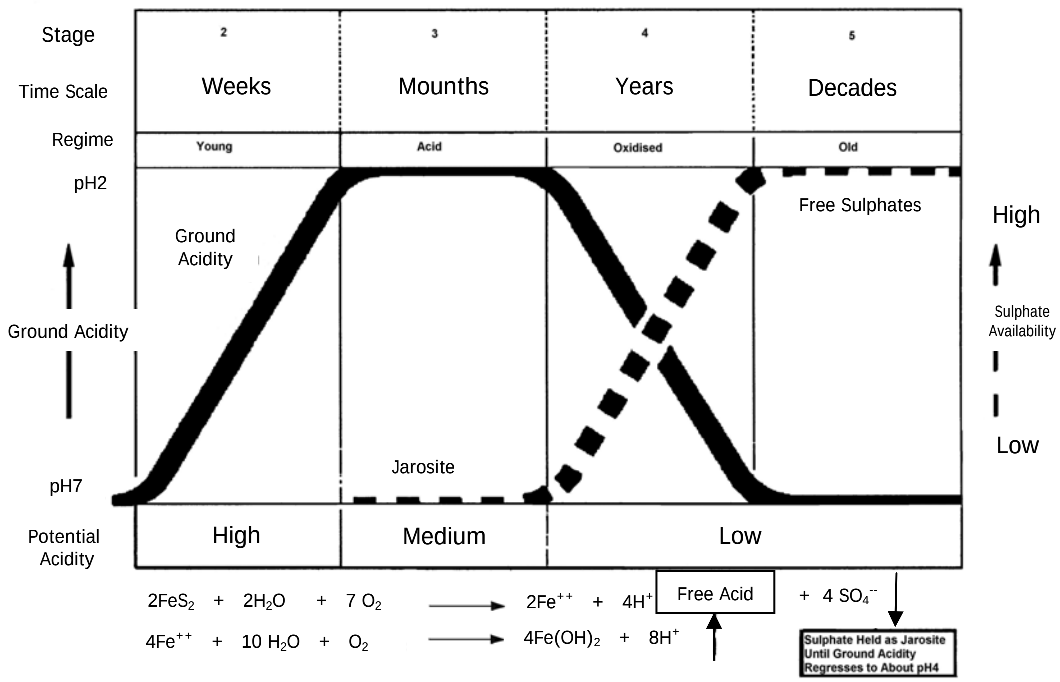

Figure 3. Acidity of Sulphirite Production from Oxidation processes of Pyrites (After Leach et al., 1991)

Characteristic of Man-made materials from Coal Spoil Dumps

1. Types of Colliery Soils

Sherwood (1987) stated that the most common minerals that exist in 'unburnt spoils' are quartz, mica and clay minerals with small amounts quantities of pyrites, calcium carbonates, magnesium and iron. The problems of dealing with 'unburnt spoils' are that they will be altered by spontaneous combustion from oxidation of the pyrites, either in-situ or earthworks.

The oxidation process in the ground is accompanied by volume changes. Hence, some of the carbonates are converted into the corresponding sulphates; see the oxidation cycles of pyrites in Figure 3.

In spite of that, the depositions of 'burnt spoils' are dominantly having the higher of quality than 'unburnt spoils' (minestone) because, they can be used as 'road base' and 'sub-base' of materials in road construction. Further, most of 'burnt spoils' may not have been fully combusted therefore they can exhibit spontaneous combustion due to pyrites oxidation. However, obtaining these materials is not too easy as there is much less 'burnt spoil' than 'unburnt spoil'.

The gradation distributions of its particle size are randomly, from 0 to 300 mm in diameters and the particle size distributions are performed in Figure 4 for 'burnt colliery spoils' and Fig 5 for 'unburnt colliery spoils'.

Colliery Spoils are also contains of a carbon and a sulfide whilst construction materials mostly do not. By thermal treatment, i.e. burning out the carbon and oxidation of sulfides, the mineral part can be upgraded into a form, suitable for production of construction materials.

Therefore, those materials of colliery spoils on the washery plant can be separated into three types, based on the gravitational separation techniques as shown in Table 2:

- washed minestone (usable as filling material);
- ow-grade coal;
- washery sludge.

Table 2.
The chracteristics of Coal Spoil Dumps for Ash Content and Combustion Value, (J.J.M Heynena, H.N.J.A. Bolkb, G.J. Sendenc and P.J. Tummersd, 1994)

	Ash content (%-weight)	Combustion value (MJ/kg)
Untreated colliery spoils	90	4.25
Low-grade coal	40	18
Washery sludge	60	12

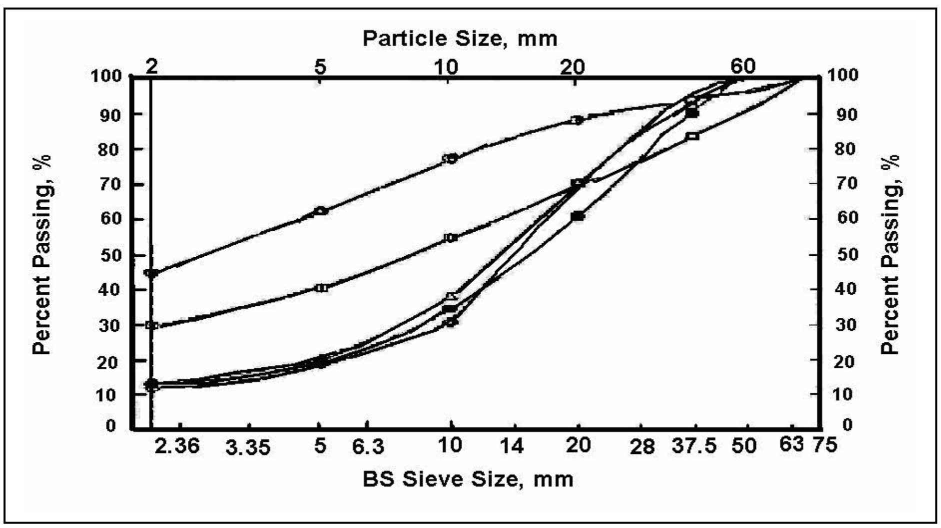

Figure 4. Particle Size Distribution of 'Burnt Colliery Spoils' (Sherwood, 1987)

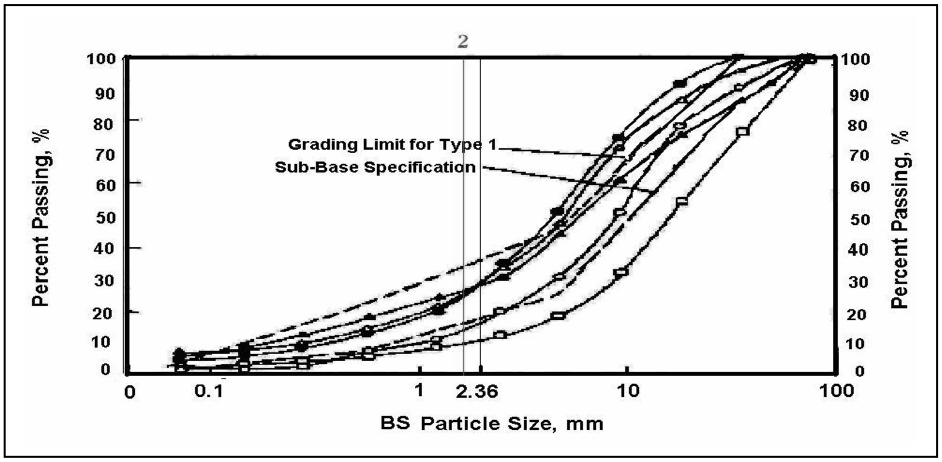

Figure 4. Particle Size Distribution of 'Un-burnt' Colliery Spoils (Sherwood 1987)

2. Recently Deposited Coal Spoil Dumps of Colliery Spoils in Some Areas

As man - made materials referring to the mostly literatures, the Coal Spoil Dumps are recognized as 'Colliery Spoils'. They are two types of waste from coal mining, 'Colliery Discard' and 'Fine Discard'. The coal spoil dumps identified in Indonesia is in part of East Kalimantan and have covered the large many areas.

Due to easily change on their characteristic either in chemically or physically and a parallel with their deposition used as the foundation of roads, therefore affecting the instability of roads which can be founded as road failures in many places. Hence, if the coal spoil dumps are used as an embankment fill without the cause concerns of possibility changes on their characterization, may shows the problems of instability, as like as the occurrences of roads were built in East Kalimantan.

It has been mentioned before that most of 'un-burnt' colliery spoils is mostly founded as well as in East Kalimantan as shows in Figure 6 therefore they can be used as 'fill materials', 'road base' and 'sub-base' of materials in road construction however cause concerns perhaps should be noted before utilizing them.

However, in some areas, the occurrences of the Colliery Spoils are recognized as slurry or fine coal refuse with particle sizes less than 2 mm. Some types of Colliery Spoils are found in open-cast coal mining pit areas, in heaps close to pitheads and processing plants are shown in Figure 7.

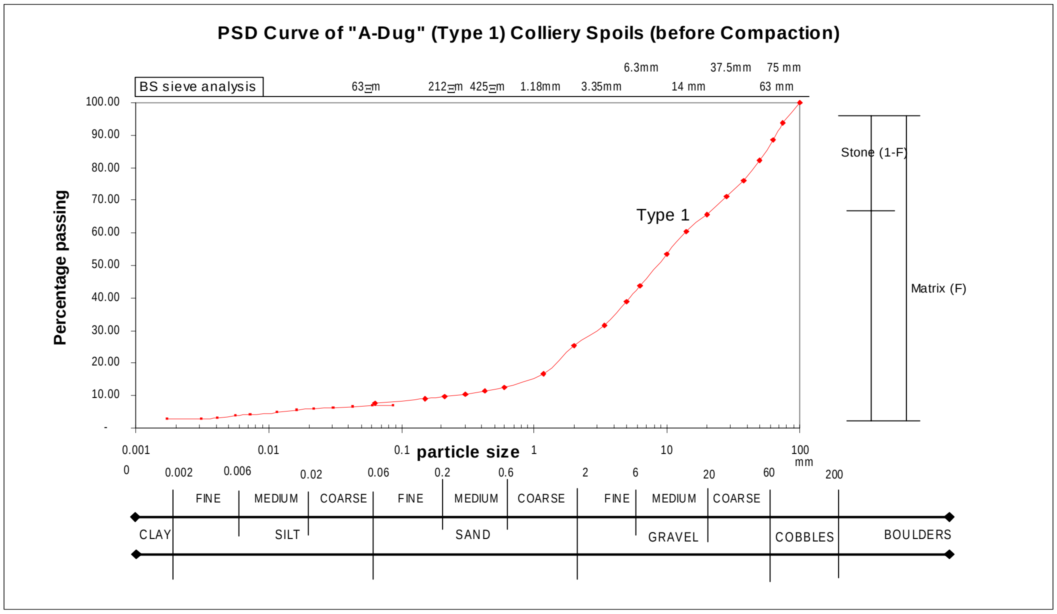

Figure 5. Particle Size Distribution (PSD) Curve of Colliery Spoils, Eddie Sunaryo Munarto (2003)

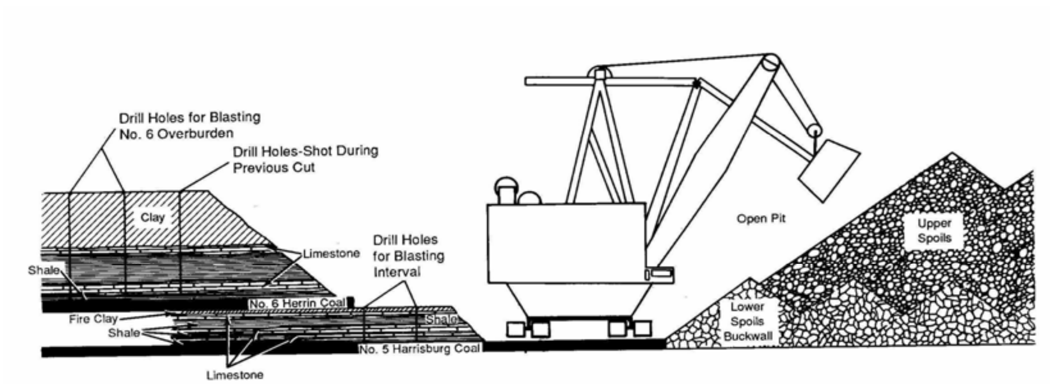

Figure 6. Initial Stratigraphy and Mining Sequences (After Davis, 1990)

Utilizing Solutions of Colliery Spoils as Sub-standard Materials of Man-made by Products for Construction Materials

It has been previously mentioned that Man-made Materials are derived from Colliery Spoils are mostly affecting to the decreasing quality of the groundwater, which is threatened by these uncovered heaps, such as pollution, Goumans, at al (1994). In order to prevent groundwater pollution in the future, the best solution is by removing the spoil dump heaps.

An appropriate approach to accomplish this aim is to upgrade the coal spoils by thermal treatment towards basic materials for production of construction materials. Thus, by accomplishing a total, high valued re-use of coal spoils can be recovery of the remaining energy content. The basic ideas of this approach (in principle) can be used in any region where coal spoils and/or low-grade coal deposits are available.

Referring to this perspective, Novem of the Netherlands Agency for Energy and the Environment, and Mauran B.V. (1994), investigated a plan for a relatively small upgrading unit (50 MW-fuel) in the municipality of Kerkrade, Limburg. Those approach on above was investigated with based on by upgrading thermal treatment, which aimed investigation applied in the municipality of Brunssum, The Netherlands, at a scale of about 150 MW-fuel.

Production of ceramic limestone as an end-product was found to be a very interesting option on the utilizing coal spoil dumps in many regions. This is based upon a result of an integrated processing facility based on proven technologies that will be able to upgrade coal spoil deposits into:

- Basic minerals to be used for the production of construction materials (within a high valued re-use), simultaneously recovering,
- The remaining energy-content, i.e. (2) electricity and (3) heat. The facility itself can very likely be a basis or crystallization point for innovative building material industry, thus causing an economic stimulus for the region..

Encouraging the Colliery Spoils performed from Fluidized Bed Combustions

Fluidized Bed Combustion (FBC) is a proven technology especially suitable for the combustion of smaller particles containing a relative low caloric value using a shaft furnance. In this case, coarser particles > 20 mm can be burnt in a shaft furnace [R.H. Perry and D. Green, 1984].

A FBC-furnace can be described as a cylindrical vessel with a porous bottom plate. The combustion air is blown through this bottom plate with such velocity that the particles in the furnace will be lifted and be whirled; then, they get in a socalled "fluidized" condition. When fluidized the solids behave almost like a liquid.

Because of this, process conditions like temperature, heat exchange, residential time etc. can be well controlled. Furthermore additives (such as limestone for SO_2 emission reduction) can be added easily.

In figure 8, a principle scheme for a FBC furnace is drawn. This is a so-called "slow" or "bubbling" fluidized bed.

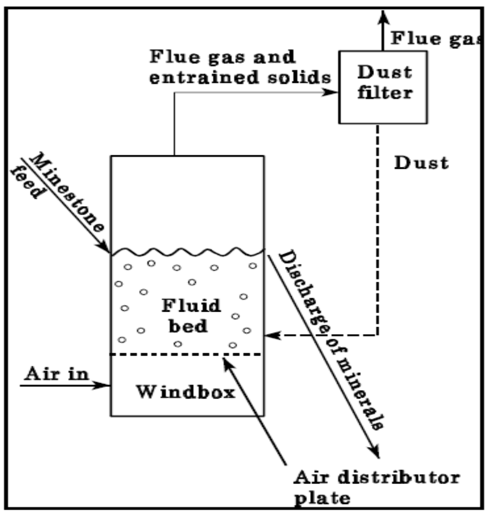

Figure 7. Principle scheme of a Fluidized bed system, (after J.J.J.M. Goumans,H.A. van der Sloot and Th.G. Aalbers, 1994)

Producing Coal Spoil Dumps as a high-valued construction materials

It is known that by using the proper upgrading technologies, colliery spoils can be used as a basic material for the production of high-valued construction materials [J. Leonhard and Th. Schieder, 1990]. As colliery spoils can still contain a relatively large amount of coal (especially older, low-efficient washed minestone can contain up to 40 % coal), energy recovery is also an interesting feature.

In the Netherlands, the development of a Colliery Spoil Upgrading Facility (CSUF) was initiating an integrated for producing construction materials and as well as for fulfilling the needs of and electricity and heat (which can be usually used in greenhouses and/or municipal heating systems) from colliery spoils in processing plant, J.J.M. Heynen, G.J. Senden and P.J. Tummers, 1993.

The CSUF process is based on a combined Fluidized Bed / Shaft Combustion (FBC) reactor (Figure 8) in which the colliery spoils are burnt-out to a sufficient high extent. As a result of the carefully chosen burning conditions, the combustion products are suitable for producing high-valued construction materials, whereas the produced electricity and heat are useful by-products.

The detailed explanation on utilizing the process which was recommended by the CSUF is given in Figure 9.

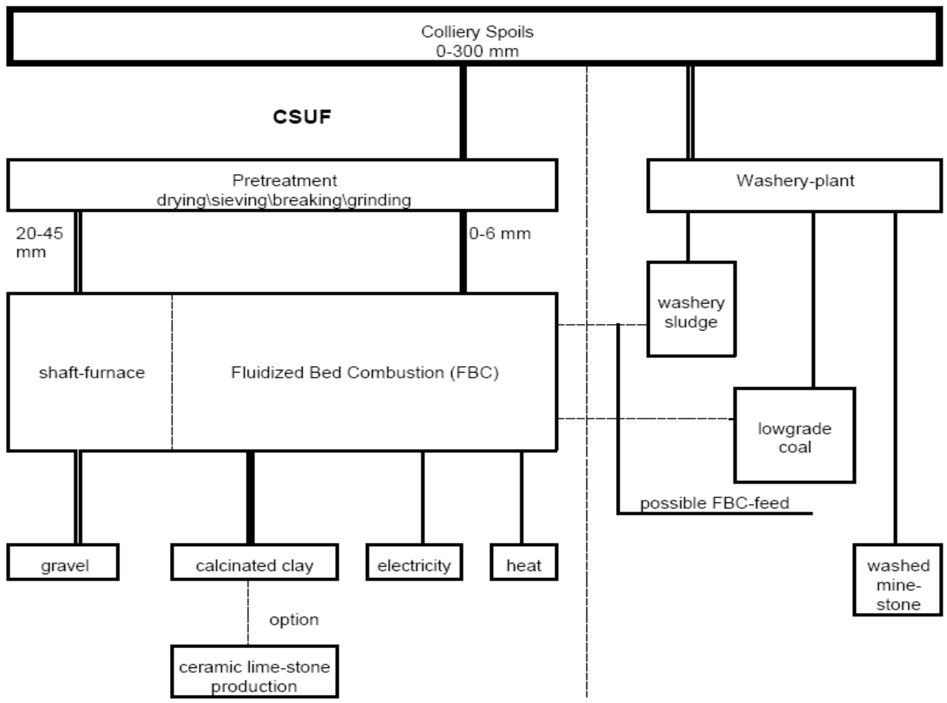

Figure 8. Flow-sheet of the Colliery Spoil Upgrading Facility (CSUF) (after J.J.J.M. Goumans, H.A. van der Sloot and Th.G. Aalbers, 1994)

Optimizing the Colliery Spoil performed from Upgrading Facility (CSUF) for material constructions

The CSUF was adopted in the Netherlands and was planned to be situated in the municipality of Brunssum which is the site in which the colliery spoil was deposited about 30 million tonnes. There are two categories can be separated based upon their particle size gradation:

1. The materials will be fed into a pre-treatment unit (drying, breaking, sieving, grinding) from which have the fine particles (0-6 mm) and will be fed into the FBC (Fluidized Bed Combustion)–unit.
2. The coarser particles (20-45 mm) will be fed into the shaft furnace. This will be resulting two types of mineral product:
   a. calcinated clay, applicable as a raw material for production of construction materials and broken burnt-out minestone, for direct use as gravel and fillers.
   b. low-grade coal and the washery sludge (derived from minestone washery plant has just been taken into operation on this colliery spoil deposit)

which can very well be used as an additional feed for the FBC. Thus can be acting as a replacement for a caloric equivalent of unwashed colliery spoils.

If done so, the CSUF can be operated complementary to the washery-plant, thus increasing the possibilities for re-use of the colliery spoils. A flow-sheet of the CSUF process has been drawn in figure 9.

The Beneficial and Precaution of Environmental Aspect Concerns of the colliery Spoils from CSUF

The Beneficial Environmental Aspect Concerns

The operation of the CSUF can lead to positive effects on the environment, such as follows:

1. a likely long term groundwater pollution source can be eliminated;
2. by using upgraded colliery spoils as a basis for the production of construction materials, primary raw material resources (sand, clay, gravel etc.) can be preserved and the amount and/or size of landscape destroying sand/clay/gravel exploitations can be reduced, then ;
3. burnt-out minestone can be produced without uncontrolled emissions (e.g. SO_2) to the air;
4. large obstacles in the landscape (the colliery spoil heaps) will be removed.

The Precaution Environmental Aspect Concerns

With respect to the environmental effects of the upgrading process itself, the following precautions can be taken:

1. reduction of emissions to the air by process-integrated measures; lime supplied in the reactor-feed will cause a significant SO -emission reduction (85 to 90%); NO -emission 2 x reduction can be reached by staged combustion at low temperatures (down to 200 mg/m3) and dust emissions can be reduced by a dust filter (to 20 mg/m3). These measures together will assure low emission concentrations.
2. minimization of the needed amounts for process and cooling water, e.g. in the Dutch government's policy, there is to restrict the further use of groundwater; at the planned location, or in another words no surface water is available.

The potential leachability of the CSUF-products has been looked at. Based on available information on the composition and a few cascade leaching tests of locally available colliery spoils, it is deducted that the composition and leachability of the (at low temperatures, 850^0 C) burnt-out CSUF-products will be similar to natural clay soils and thus will fully comply with the Dutch Construction Materials Act. This however should be confirmed by tests at the actual CSUF-products.

In the Netherlands an Environmental Impact Assessment (EIA) is compulsory and will be dealt with by the authorities together with the demand for legally required permits. By carefully balancing the complementary environmental effects and costs of extra emission reducing measures, the authorities will have to impose well-considered requirements (described in the permits to be given). Eventually, the EIA should balance the positive and negative environmental effects and compare several variants with each other and with the socalled zero variant: when nothing at all will be done.

Due to a number of requirement is still in discussing, the actual Environmental Impact Assessment has not yet been carried out however, the preliminary inventory has been made and discussions with governmental authorities confirmed that was giving no major constrains are to be expected.

Economic Aspect Concerns of the CSUF

Financial calculations

Expertise and experience with similar projects, preliminary economic calculations for a CSUF have been made based on the location in Brunssum R.H. Perry and D. Green (1984). Further, it was also stated that financial data were calculated over FBC capacities in the range of 50 to 200 MW fuel. An overview of cost of mineral product of coal spent waste with the varieants as 150 MW – fuel is showed in Table 3.

Table 3.

Overview of Cost of Mineral Product of Coal Spent Waste in some selected variants at 150 MW - Fuel

Overview of Costs of Mineral Product in some selected variants at 150 MW-fuel

Electricity price (Dfl/kWh)	Costs of mineral product (Dfl/tonne, total average)			
	Input: Colliery spoil only (1,564,000 t/a) Output: calcinated clay (915,000 t/a) and burnt-out minestone (493,000 t/a)		Input: Colliery spoils (695,000 t/a) plus washery sludge and low-grade coal (80,000 t/a each) Output: calcinated clay (487,000 t/a) and burnt-out minestone (219,000 t/a)	
	No investment premium	40 % investment premium	No investment premium	40 % investment premium
0.06 to 0.12	30 to 17	22 to 8	45 to 17	30 to 3

Because most of these figures are regarded as confidential, at present, they will not entirely be described in this paper. However, a brief overview of the assumptions will be given below as well as the resulting Costs of Mineral Product (COMP). There are two assumptions, investment costs and operating annual costs.

Investment costs which is consist of:

Investement cost are moctly dealing with:

1. Fuel consumption: excavating, transport, breaking, sieving, drying and grinding;
2. FBC-unit;
3. Shaft-furnace;
4. Civil works, infrastructure.

Comprises of annual costs

Annual costs are influenced by a number of constraints dealing with operation and maintenance processes, there are:

1. capital costs: calculated from annuities of investment costs at an interest rate of 8 % and a life-time of 20 years. Also governmental investment premiums were taken into account, ranging from 0 to 50%
2. energy costs of fuel-preparation;
3. maintenance: 2 to 8% of respective investment costs
4. personnel (a total of approx. 80 persons);
5. miscellaneous;
6. risk and profits.

Electricity revenues:

Electricity revenue are calculated by assuming the producing capacity of the materials, and production prosesses, there are :

1. Fuel capacity, e.g. 54 MW electric power at 200 MW (FBC) fuel capacity and 13.5 MW electric power at 50 MW (FBC) fuel capacity;
2. 8000 production hours per year;
3. Electricity prices (supply to local electricity distributing company) ranging from averages 0.06 to 0.12 per kWh; preferably 0.084/kWh is considered as a basic minimum price to be obtained.
4. Potential revenues from produced heat are until now not taken into account.

Others expenditures

After calculating the annual costs and subtracting the electricity-revenues the Costs of Mineral Product (COMP) remain. Several variants in the above mentioned ranges including variants where colliery spoil is partly replaced by washery sludge and/or washed low grade coal (at zero prices) have been calculated.

Some variants on applying CSUF with a capacity of 150 MW-fuel (40.5 MW electric) is given on Table . In the 150 MW - variant the total amount of CSUF-product will fuel be about 1,4 million tonnes of product/year. In the case of replacement of colliery spoils with washery sludge and washed-out low grade coal (both approx. 80,000 tonnes/year) from the on site present washing facility, the total product amount will be about 700,000 tonnes/year.

Economic feasibility

The perspective for the option for producing ceramic limestone is very interesting from a financial point of view, the revenues for ceramic limestone can be estimated at about 80 to 100/tonne. However, costs of the autoclave end-production process still have to be added to the COMP. Because the produced calcinated clay does not need further pre-treatment and the CSUF produces heat, which can be used for the autoclave-process, it is estimated this option could be economic feasible. This should, however, be further investigated.

In particular, the market potential of this new product and technical details should be further analyzed. However, by granting an investment premium and/or higher electricity prices, the regional government can encourage the elegant ways to remove the remaining colliery spoil deposits. In that way a future threat for groundwater quality will be removed and the economic development of the region will be stimulated.

Table 4.

Overview of Cost of Mineral Product of Coal Spent Waste in some selected variants at 150 MW - Fuel

Overview of Costs of Mineral Product in some selected variants at 150 MW-fuel

Electricity price (Dfl/kWh)	Costs of mineral product (Dfl/tonne, total average)			
	Input: Colliery spoil only (1,564,000 t/a) Output: calcinated clay (915,000 t/a) and burnt-out minestone (493,000 t/a)		Input: Colliery spoils (695,000 t/a) plus washery sludge and low-grade coal (80,000 t/a each) Output: calcinated clay (487,000 t/a) and burnt-out minestone (219,000 t/a)	
	No investment premium	40 % investment premium	No investment premium	40 % investment premium
0.06 to 0.12	30 to 17	22 to 8	45 to 17	30 to 3

Conclusions and Recommendations

Conclusion

There are a number of conclusions can be stated to deal with the use of colliery spoils as sub-standard materials from man-made by products:

1. The developing infrastructure sectors are increased as a result that there have been increasingly demands for the use of Standard Materials and influenced the increasing construction costs and has been predicted to increase still future.
2. The use of Sub-standard Materials to replace the Occurrence of Standard Materials is now being strongly recommended as a solution however the Test Guides do not deal appropriate due to indicate the different results and influencing the behaviour of the actual field performance.
3. The sub-standard materials are any materials obtained either, from natural deposits that are deposited from geological processes and from man–made or industrial by products that discovered in the world in large scales are coal spoil dumps or colliery spoils and can be recognized in large areas of East Kalimantan.
4. The 'unburnt spoils' (minestone) are most found rather 'burnt spoils' and can be used as 'fill materials', 'road base' and 'sub-base' of materials in road constructions however they have the possibility changes on their characterization either physically or chemically that may induces the problems of instability

Recommendation

The following recommendations on using the colliery spoils are stated and there are an appropriate approach to accomplish on the use of sub-standard materials as material constructions, which are consist of as follows:

1. Removing or protecting and treating the spoil dump heap to prevent groundwater pollution in the future that can affect to the change environmental due to contaminations due to their characteristic change in chemically.
2. Upgrading the coal spoils by upgrading thermal treatment towards basic materials for production of construction materials at a scale of about 150 MW-fuel performed from Fluidized Bed Combustions (FBC).
3. Producing Coal Spoil Dumps as a high-valued construction materials by the development of a Colliery Spoil Upgrading Facility (CSUF) for initiating an integrated on producing construction materials as for fulfilling the needs by electricity and heat processes.

4. The Beneficial and Precaution of Environmental Aspect Concerns of the colliery Spoils from CSUF should be awarded due to the potentially of their leachability and should be tested using Leach Laboratory Test.
5. The preliminary economic calculations when a CSUF have been made to get a brief overview of the assumptions Costs of Mineral Product (COMP).

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