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TITLE **The status and use of the Indonesian national road-making materials inventory**

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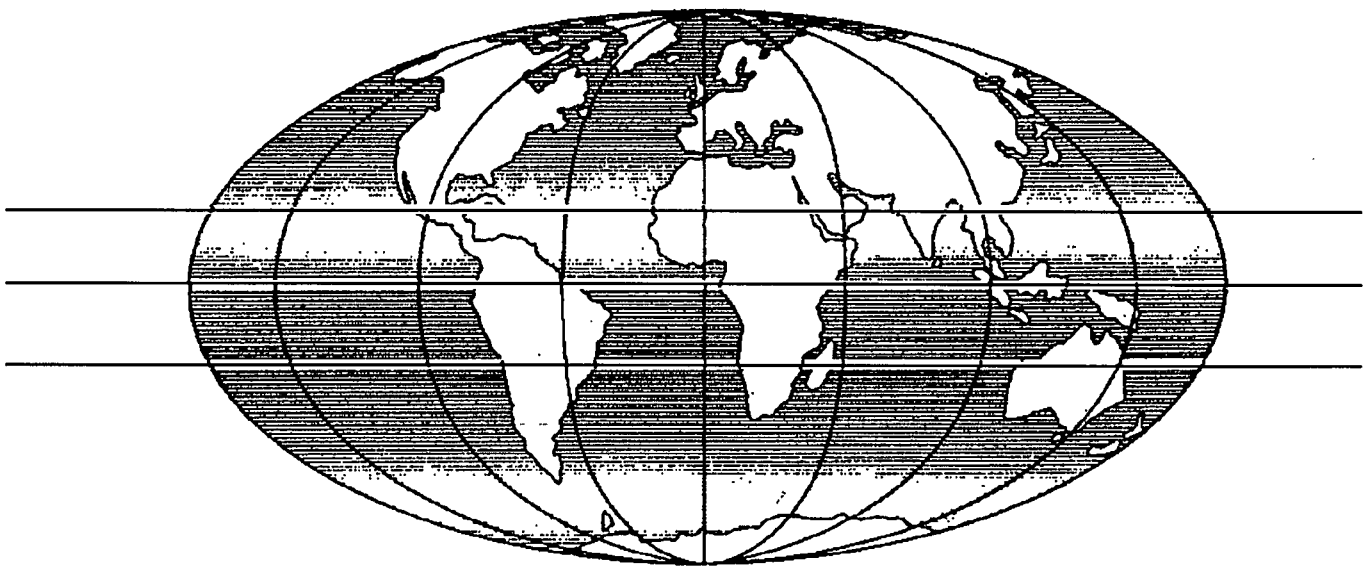

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THE STATUS AND USE OF THE INDONESIAN NATIONAL ROAD-MAKING MATERIALS INVENTORY

Benny Moestapha, P J Beaven, Tonny Heditono and D J Savage

ABSTRACT

An inventory of existing information on road materials sources from all of Indonesia's provinces has been assembled and entered into a custom built microcomputer database held at the Institute of Road Engineering in Bandung. More detailed information has been collected by surveying and testing samples recovered from most of the working or recently disused quarries in West Java with additional samples from five other provinces.

This paper describes the formation of the inventory and explains how it could be used to improve road planning throughout Indonesia. Suggestions are also given on the further development of the inventory by extending the detailed surveying to other provinces.

1.0 INTRODUCTION

The National Road Materials Inventory (NRMI) database has been set-up as a data storage and retrieval system for natural road-making materials in Indonesia. The development of the NRMI formed part of the Geotechnical Engineering Programme which in turn was part of the IBRD funded Technical Assistance and Research Training Project, Second Phase (TARP II).

This paper is intended as a guide to the use and development of the NRMI. It describes the current status of the NRMI and its applications to road network planning and construction programmes. It also presents the way in which the current framework may be developed into a fully operational and practical system at national and provincial level and indicates topics of further development in the general area of road-making materials management and research.

2.0 CURRENT STATUS OF NRMI

2.1 General Description

The National Road Materials Inventory (NRMI) currently exists as a framework of related computer database files held within a management and operating system. This database is backed by an archive of original data, photographs, reports and relevant maps.

Data within the NRMI have been assembled by three principal procedures. The Provincial Desk Study Inventory (PDSI) survey collected available data at deskstudy level from provincial offices throughout the country. The Provincial Road-Making Materials Inventory (PRMI) surveys, undertaken by IRE research staff, collected detailed information by visiting individual materials locations and filling out a series of standard data sheets. The Detailed Sources Assessment (DSA) surveys are intended to provide more accurate data utilising site investigation techniques.

2.2 Information Held Within the NRMI

The NRMI is a database of information relating to existing or recently disused sources of road making aggregate. It covers both unconsolidated and bedrock materials but does not contain data pertaining to sources or material primarily used as earthwork fill.
The types of aggregate source data that are a contained within the database fall under the following main headings:

* source location
* source definition
* material definition
* material quantity
* product definition
* product cost

Information is classified with reference to its mode of collection:-

Level 1 — Data obtained through the PDSI programme and largely uncorroborated by IRE staff.

Level 2 — Data obtained through PRMI programmes by IRE staff.

Level 3 — A strictly limited amount of DSA data obtained by detailed surveys sub-surface investigations undertaken by IRE staff.

These levels of detail may also be related to a standard definition of resources and reserves where, in general terms,:-

level 1 = an inferred resource/ reserve - PDSI data
level 2 = an indicated resource/reserve - PRMI and some PDSI data
level 3 = a measured resource or reserve - DSA data.

The PDSI surveys were initiated in order to form a foundation framework from which to build up the NRMI through increased numbers of PRMI surveys, which will eventually form its principal data source. Tables 1 to 5 summarise the data types held under each heading by PRMI files. In addition, important support information with respect to the status of the data is also held (Table 6). Information stored under the PDSI heading is summarised on Table 7. There are obvious problems with respect to the wide variability in the amounts and reliability of the PDSI data. In an effort to guide potential users in this regard the PDSI data is classified in terms of reliability (Table 8).

The current status of the data held within the NRMI is summarised in Table 9. This indicates that although aggregate source information is available for all provinces, the majority is at level 1 rather than level 2. In the next stage of the development, starting this year, it is intended to increase the number of PRMI surveys in cooperation with provincial collection teams. The structure of this work will be based on the existing PDSI surveys.

TABLE 1 SOURCE LOCATION INFORMATION

Province Kabupaten Kecamatan Source name and reference number Nearest Desa or Kampong Adjacent river (if relevant) Definition of nearest link road Chainage of access road off that link Access condition and length Relevant topographic map Map reference, either UTM grid or lat/long.

TABLE 2 SOURCE DEFINITION

Source owners and operators Site operational status Methods of excavation Methods of processing Site utilities, water, electricity etc General geology Relevant geological map Relevant Bakosurtanal land system map Land system code and landform Potential hydrological problems Environmental impact Types and amounts of overburden Working face heights

TABLE 3 MATERIAL DEFINITION

Material type Percentage of material types at each location Standard materials laboratory test results [Unconsolidated Materials] Field estimation of grading Particle/clast shape, angularity and texture Particle/clast type and strength Field estimates of particle/clast density & porosity Types and amounts of deleterious material Material mass strength Mass structure [Indurated Materials] Detailed bedrock type and texture Mineralogy Weathering grade Types and amounts of deleterious material Bedrock mass form Discontinuity types, spacing. Block shape Mass strength and Schmidt Rebound No. Effect of soaking on strength Estimates of material density and porosity

TABLE 4 MATERIAL QUANTITY

Estimate of proven reserves Estimate of total reserves (proven + potential) Field evaluation of development constraints: physical hydrological economic

TABLE 5 PRODUCT DEFINITION AND COST

Current usage
Field estimate of potential usage
Estimate of actual quality
Estimate of potential quality
Processed material size
Processed material shape, angularity & texture
Processed material strength
Estimate of processed material, density and porosity
Standard aggregate test results
Current production rate
Current product cost

TABLE 6 SUPPORT DATA

Survey reference number
Survey team identification
Dates of inspection
Photograph references
System dates, operator
Name of survey
Verification codes
Sample identification codes
Additional notes

TABLE 7 PDSI DATA SETS

Survey reference number
Province
Kabupaten
Source name and reference number
Nearest Desa or Kampong
Adjacent river (if relevant)
Definition of nearest link road
Chainage of access road off that link
Topographic map reference
Map reference, either UTM grid or lat/long.
General geology
Geological map reference
Bakosurtanal land system map
Land System code number
Material type
Petrographic names
General product types
Reference to laboratory data
Reference to source data
Additional data
Date of data
Validation codes

Data is held largely in a combination of codes and numeric information within the database files. Full details of these database files together with their structure are contained within the NRMI Manual. Summaries of the data currently held in the NRMI, together with relevant guides to the codes, are included in the reports held at IRE.

TABLE 9 CLASSIFICATION OF RSC DATA SET AVAILABILITY AND RELIABILITY

Class	Location	Environment	Material
1 Excellent	All relevant data sets present including co-ordinates calculated from accurate information.	Full geological and land system data based on accurate location data.	All relevant data present and from reliable sources.
2 Good	All road link and river data present where relevant. Either reliable chainage or co-ordinate data.	Full geological and land system data although some estimation of location on maps may have been necessary.	Reliable data. Detailed geology data may be missing
3 Fair	Gaps in relevant road link or river data. Missing co-ordinate data	LS code present although may be estimation. Poor or non-existent geological data	Two out of geology, product or lab rel. data sets missing Data generally reliable
4 Poor	Unreliable, estimated or missing road link data.	Geological data present only	Only one reliable data set present.
5 Very Poor	No location data apart from general kecamatan, desa or kampong information.	Only unreliable or poor geological data.	Vague or extrapolated data only.
6 None	None only	No significant data	No significant data

2.3 Access to NRMI Data

Data may be disseminated from the NRMI database in number of ways:

within IRE research reports
as individual data reports or lists
on computer disk (in FoxPro or ASCII format)
as a direct computer to computer link.

Apart from the situation where the NRMI is acting as a service system to larger databases (see section 3.1 below) the commonest means of accessing data is by utilising the system's own reporting facility. This facility currently employs the Report Writer programme to design report forms and establish queries for the database. Report forms may be custom designed for specific queries or may be one of a number of standard sheets designed for this purpose.

The data output to the above reports may be defined by user-queries related to a number of material, source or product characteristics. Typical queries illustrating the flexibility of the system are listed in Table 10.

3.0 THE NRMI AS AN AID TO BINA MARGA ACTIVITIES

3.1 Input to Road Management

Bina Marga (BIPRAN) currently utilises two database systems, the IRMS and BMS, which aid national/provincial road management and bridge management respectively. The NRMI is potentially suitable for adoption as a service database of aggregate information to both systems.

TABLE 9 NRMI CURRENT STATUS

PROVINCE	NUMBER OF SOURCE LOCATIONS					
	PDSI	DATE	PRMI	DATE	DSA	DATE
Irian Jaya	95	05-92				
Aceh	289	08-92				
Sumatera Utarah	416	08-92				
Sumatera Barat	172	08-92				
Riau			19	1991		
Jambi	25	06-92				
Bengkulu	87	02-92				
Sumatera Selatan			37	1988		
Lampung	15					
Jawa Barat			666	1988-92	2	1991
DKI Jakarta						
Jawa Tengah	255	05-92				
DKI Jogyakarta	74	05-92				
Jawa Timur	377	05-92				
Kalimantan Barat	56	02-92				
Kalimantan Tengah	179	02-92				
Kalimantan Timur	71	02-92				
Kalimantan Selatan	319	02-92				
Bali	46	03-92				
N.T. Barat	19	03-92				
N.T. Timur	17	03-92				
Timor Timur	25	02-92				
Sulawesi Utarah	61	12-91				
Sulawesi Tengah	147	07-92	42	1992		
Sulawesi Selatan	513	12-91				
Sulawesi Tenggara	116	06-91	25	1992		
Maluku			27	1991		

Initial discussions between IRE and BIPRAN have indicated the compatibility of the systems and files. The method of location of aggregate source by link number and chainage is generally in agreement with the procedure used by the IRMS, although a more detailed data matching exercise may have to be undertaken to deal with those sources located by kabupaten and local road link numbers. The parallel location system using UTM grid references could be of used for this purpose.

The NRMI contains a large variety of information not all of which would be of immediate use to either the IRMS or BMS. It may be advantageous, therefore, in discussions with the interested parties, to arrive at a series of key data fields to use as a primary service data file, with the remainder of the NRMI data being kept in reserve. A preliminary listing for such a primary file is presented as Table 11.

TABLE 10 TYPICAL STANDARD NRMI QUERIES

Data from within an administrative area (Province, Kabupaten or Kecamatan).
Data from within an area defined by grid references.
Data from a particular river system.
Data from along a defined link road or a defined access distance from that link road.
Data from a particular geological formation or land system
Data from a particular survey.
Data above a certain reliability rating.
Data may be composed of any of the fields in the database and may itself be defined by conditions eg:-
materials with sand fraction >75%
materials meeting particular design specification
sources of a certain size or potential
The queries may be requested as individual data sheets on particular sources or as lists of varying complexity.

Besides its utilisation as a service database, the NRMI can also supply relevant data direct to either road planning or road construction activities through its standard query-report system.

3.2 Development at Provincial Level

The development of the NRMI system within the provinces could provide a significant resource management tool at that level. Possible relationships between the NRMI, Bina Marga and provincial offices are schematically presented on Figure 1.

Proposals for the staged development of the NRMI system at provincial level are outlined below:-

1 Formation of a team of NRMI trainers based at IRE.

2 Identification of suitable province to use as a pilot area for the training scheme.

TABLE 1: SUGGESTED LIST OF KEY DATA FOR IRMS USE

Survey reference number
Province
Kabupaten
Source name and reference number
Nearest Desa or Kampong
Adjacent river (if relevant)
Definition of nearest link road
Chainage of access road off that link
Access condition and length
Map reference, either UTM grid or lat/long.
Site operational status
Methods of excavation
Methods of processing
General geology
Potential hydrological problems
Environmental impact
Material type
Percentage of material types at each location
Only key materials laboratory test results
(Unconsolidated Materials)
Field estimation of grading
Particle/clast shape, angularity
Particle/clast type
Types and amounts of deleterious material
Material mass strength
(Indurated Materials)
Detailed bedrock type
Types and amounts of deleterious material
Discontinuity types, spacing.
Block shape
Mass strength
Estimate of proven reserves
Estimate of total reserves (proven + potential)
Current usage
Estimate of actual quality
Estimate of potential quality
Processed material size
Processed material shape, angularity
Only key aggregate test results
Current production rate
Current product cost
Dates of surveys
Verification codes

3 Training of relevant staff in the identified province in use of the NRMI and its applications, including the development of province-kabupaten relationships.

4 Assuming the pilot scheme is successful then the logical next stage is the development of the NRMI transfer to other provinces or groups of provinces.

5 Finalisation of the lines of communication and responsibility between the provinces, Bina Marga and IRE into a functional national network.

FIGURE 1 NRMI OPERATIONAL FRAMEWORK

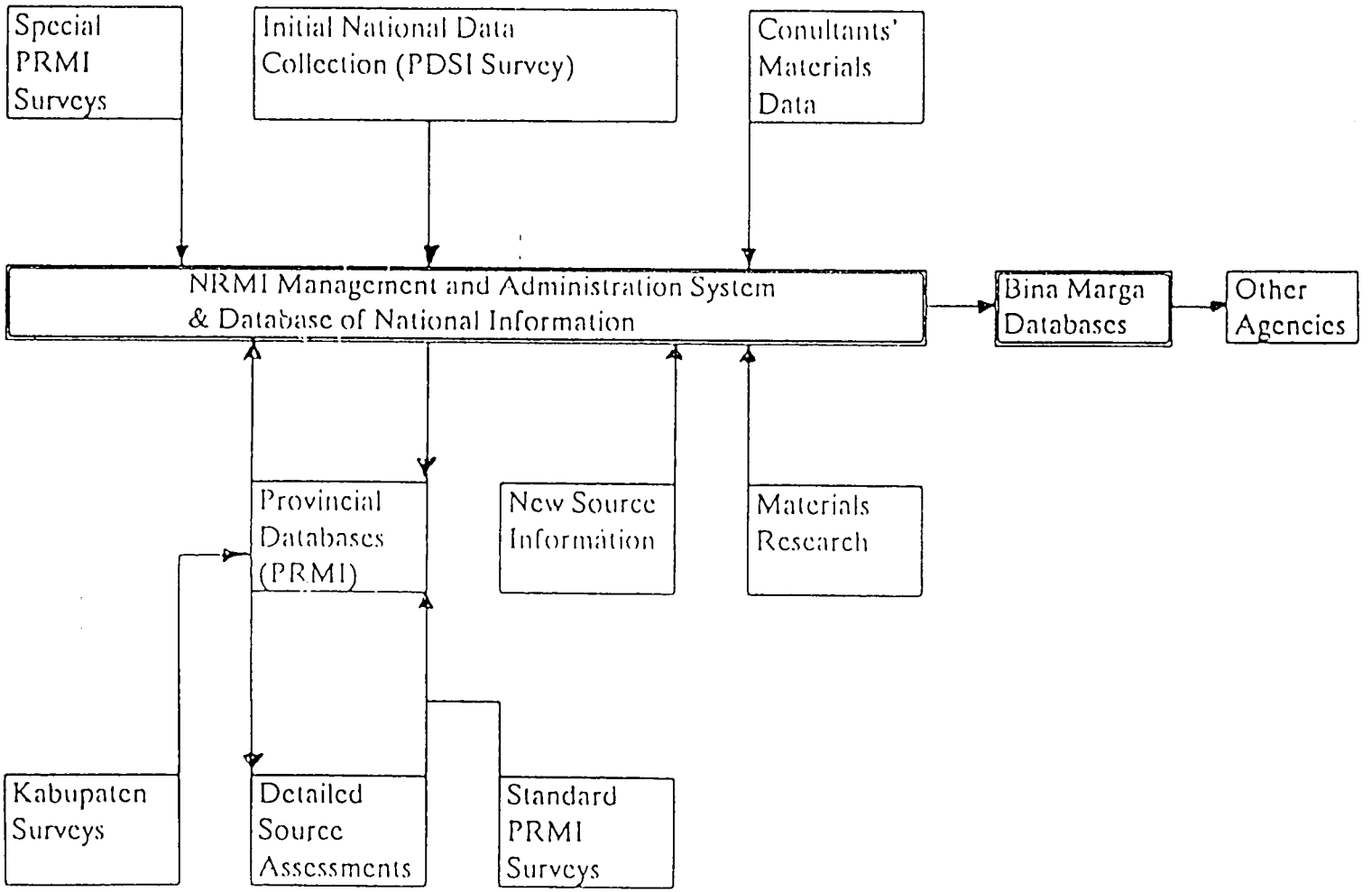


TABLE 12 MINIMUM PROVINCIAL NRMI HARDWARE REQUIREMENTS

Computer:	AT 386/21MHz with 4Mb RAM 40 Mb hard disk
	Keyboard
	Super VGA Monitor
	Mouse
	Modem
Printer:	Epson LQ 1050

TABLE 13 STANDARD TESTS FOR USE WITH PROVINCIAL NRMI

Water Absorption
Specific Gravity
Los Angeles Abrasion
Aggregate Impact Value
Soundness
Stripping
Compaction/CBR
Atterberg Limits
Particle Size Analysis

Items 1 to 3 above are the subject of proposals for the next Training and Research programme at IRE which is due to start later this year. The move from stage 3 to stages 4 and 5 is a major one involving considerable investment in hardware and manpower resource; Table 12 contains a suggested list of the hardware required for each provincial RMI operation.

Parallel to the above development must be the expansion and upkeep of the data within the NRMI system. This can either be achieved through Bina Marga's own resources or by contracting data collection programmes to suitable consultants.

The fully operational system would require good information feedback at all levels and the development of working relationships between the provincial materials officer and the Kabupaten officers could be crucial. In this regard the use of kabupaten data collection forms could be advantageous whereby basic data on sources could be collected or updated prior to full PRMI type surveys in key areas if required.

Laboratory testing at provincial level could be kept to a minimum of key tests relevant to the material or product types (Table 13). The Aggregate Impact Value test, although not as yet a nationally utilised test, is recommended because of its straight forward procedure and relatively simple apparatus. It also has the advantage of being readily adaptable to research programmes concerned with material degradability.

A major concern however is the potential confusion with regard to the current IRE standard for the AIV procedure which is not the same as the original BS812 standard. By eliminating the initial use of a sample measuring cup a significantly larger amount of material is tested in the IRE test and the resultant AIV values are of the order of only 50% of BS812 values.

4.0 FURTHER APPLICATIONS OF THE NRMI

4.1 Liaison with Bakosurtanal

A potential liaison has been proposed with respect to the exchange of information between Bakosurtanal and the NRMI. Bakosurtanal has the responsibility to prepare inventories of national resources and appreciates the potential use of the NRMI as a data source. This liaison has major advantages for the IRE not only because of access to relevant terrain mapping data, but also because of the potential tie-in with Bakosurtanal's progress on map digitisation and the development of a GIS system of data dissemination.

4.2 Resource Exploration

The NRMI can form both a starting point and framework for the exploration and assessment of road-making materials. It provides initial data for exploration programmes as well as a framework for storing and manipulation of data. The overall system also provides guidelines on data collection procedures, on data manipulation and on dissemination.

The application of GIS techniques has significant potential in the development of integrated exploration and assessment programmes, these may be possibly enhanced by the incorporation of Expert System procedures.

4.3 Material Resource Reports

The NRMI is able to provide basic information for the compilation of reports or guides on the specific areas or materials within such areas. In other words the point data contained within the NRMI could be turned round and expanded to form the basis for such reports as, for example,:

"The Laharic Deposits of West Java and Their Utilisation in Road Building"

or

"The Road-Making Materials Resources of East Kalimantan".

Such reports have formed the basis for resource management in the UK for a number of years and would seem to be a logical extension of the NRMI concept.

4.4 Road-Making Materials Research

One of the initial objectives of setting up the NRMI programme in 1988 was as a potential research tool into aggregate performance and the relationship between aggregate source and terrain. To this end the NRMI has been developed to include a substantial aggregate testing element and to include relevant data on terrain systems and landform.

The utilisation of the Bakosurtanal Land System maps has been a major factor in the derivation of terrain-resource relationships. These Indonesia-wide land systems provide a sound basis from which to progress to more detailed relationships, perhaps involving more specific geological or land facet or element data. This work has major benefits in the field of source exploration, particularly in more remote areas of Indonesia.

As an example of the sort of relationships that can be developed Table 14 presents a printout of material source types versus land systems and land system groups in West Java and Figures 2 and 3 relate aggregate quality to terrain groups.

The NRMI Laboratory data collected and stored within the NRMI forms a considerable database of aggregate properties information. Examples of the programmes of materials research are outlined below.

1. Development of aggregate testing procedures and programmes of direct application to Indonesian materials. Work already started in this field includes the examination of the problems of testing aggregate sources of highly variable composition.
2. More extensive research into aggregate properties associated with particular material types, geological formations and terrain groups.
3. Development of testing procedures more closely allied to the in-service performance of aggregates. This research should be conducted in close conjunction with that being undertaken with respect to asphalt mix designs. Topics that have already been discussed are the use of the Ravelling Test and the detailed microscopic investigation of aggregate condition from road samples.

5.0 DEVELOPMENT OF RESEARCH BEYOND THE NRMI

5.1 Overall strategy

The NRMI programme has, to date, been largely concerned with the collection and dissemination of factual data regarding the occurrence of aggregate sources. The previous section has dealt with development possibilities within its present framework. There are, however, further topics associated with the general area of road-making material resources outside this framework, but which could be very relevant to its further expansion. These research topics could be developed to provide data and guidance to specialised sections within the NRMI database management system.

WEST JAVA MATERIAL TYPES & PROVEN RESERVES VS GROUPS OF LAND SYSTEMS

LAND SYSTEMS	TERRAIN PROVINCE	BAKOSURTANAL LAND SYSTEM GROUP	Nos OF SOURCES IN EACH MATERIAL GROUP *																PROVEN RESERVE GROUPS **								
			Aa	Ab	Ac	Ad	Ae	Af	Ba	Bb	Bc	Bd	Be	Bf	Bg	Bh	Bi	Bj	Bk	1	2	3	4	5	6	7	8	9
1-3	I	COASTAL & BEACH DEPOSITS	0	0	0	0	0	0	1	0	0	1	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0
4	II	INTER-TIDAL SWAMPS	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0
5-10	III	ALLUVIAL PLAINS	10	5	1	0	1	0	53	4	0	7	8	0	0	0	0	0	0	24	24	17	10	9	2	1	1	0
11-13	IV	ALLUVIAL VALLEYS	2	0	3	3	3	0	57	0	0	0	13	0	0	0	0	3	0	29	18	10	4	4	2	2	0	0
14	V	NON-VOLCANIC, GENTLY SLOPING ALLUVIAL FANS	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
15-18		VOLCANIC, GENTLY SLOPING ALLUVIAL FANS	1	1	1	0	1	0	16	0	0	0	31	0	0	0	0	0	0	10	3	6	5	5	2	4	0	0
19-21		MODERATELY SLOPING VOLCANIC FANS	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
22-28		LAHARIC FANS/SLOPES	5	2	8	0	0	0	21	0	0	0	7	0	0	0	0	0	0	13	5	5	2	2	2	1	0	0
29-30		RAISED COASTAL PLAINS/BEACHES	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
31-34	VI	ALLUVIAL TERRACES	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
35-38		KARSTIC/CORAL PLAINS	0	0	0	3	0	0	1	0	0	0	0	0	0	0	0	0	0	2	0	1	1	0	0	0	0	0
39-42	VII	VOLCANIC PLAINS	3	1	2	0	0	0	29	0	0	0	7	0	0	0	0	0	0	22	7	3	1	0	0	0	1	1
43-49		UNDULATING SEDIMENTARY PLAINS	0	0	0	2	0	0	16	0	0	0	9	0	0	0	0	0	0	8	4	2	4	2	1	0	0	0
50-53		UNDULATING VOLCANIC PLAINS	3	0	3	0	0	0	6	0	0	0	1	1	0	0	0	2	0	6	1	1	3	0	0	0	0	2
54-55		ROLLING SEDIMENTARY PLAINS	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2-53,56-64		ROLLING PLAINS/PLATEAU-TUFFACEOUS	5	1	1	0	0	0	12	0	0	0	15	0	0	0	0	2	0	8	5	2	1	4	3	0	0	1
65-69		ROLLING PLAINS/HILLOCKS/PLATEAUS-CALCARECUS	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0
70-71		LIMESTONE PLATEAU	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0
72-77		HILLOCKY RIDGES/PLAINS-SEDIMENTARY	1	0	0	0	0	0	6	0	0	0	1	0	0	0	0	0	0	2	1	2	1	0	0	1	0	0
78-86		HILLOCKY PLAINS - TUFFACEOUS SEDIMENTS	5	4	0	0	0	0	11	0	0	1	1	0	0	0	0	0	0	14	3	1	3	0	0	0	0	0
86		HILLOCKY PLAINS - XLINE TUFF	0	0	0	0	0	0	1	0	0	0	1	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0
87-91		HILLOCKY PLAINS INTERMEDIATE/BASIC VOLCANICS	11	5	24	4	0	0	48	0	0	1	16	0	0	0	0	4	0	53	13	5	5	5	1	1	1	0
93-99	VIII	STEEP HILLS/RIDGES - CALCAREAUS/KARST	3	2	10	0	13	0	9	0	0	0	4	0	0	0	0	6	0	20	5	1	6	1	1	1	1	0
100-102		RIDGES ON SEDIMENTARY ROCKS	0	0	1	0	0	0	2	0	0	0	0	0	0	0	0	0	0	1	0	2	0	0	0	0	0	0
104		STRONGLY DISSECTED LIMESTONE RIDGES	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
103,105-108		RIDGES ON TUFFACEOUS SEDIMENTS	7	2	2	1	0	0	14	0	0	0	5	0	0	0	0	0	0	15	4	2	0	0	0	0	0	0
109-112		STEEP HILLS & RIDGES ON BASIC VOLCANICS	27	11	9	1	2	1	20	0	0	0	4	0	1	0	0	3	0	33	12	7	8	2	3	1	0	0
113-114	IX	STEEP HILLS & RIDGES ON ACID VOLCANICS	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
117		MOUNTAIN RIDGES ON SANDSTONE/MARLS	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
118		MOUNTAIN RIDGES ON TUFFACEOUS SEDIMENTS	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
119-20,122-4		VOLCANIC/STRATOVOLCANIC CONES	8	5	15	0	0	0	13	0	0	0	2	0	0	0	0	1	0	20	5	3	2	1	3	0	0	0
121		MONTAIN RIDGES ON INTERMEDIATE/BASIC VOLCANIC	23	18	3	0	0	0	7	2	0	0	1	0	0	0	0	0	0	8	7	4	7	8	2	4	1	1

Notes: *: see table A1, Appendix A. **: See table B1, Appendix B

FIGURE 2 ACTUAL QUALITY OF SOURCES IN W. JAVA TERRAIN PROVINCES

FINE AGGREGATE ACTUAL

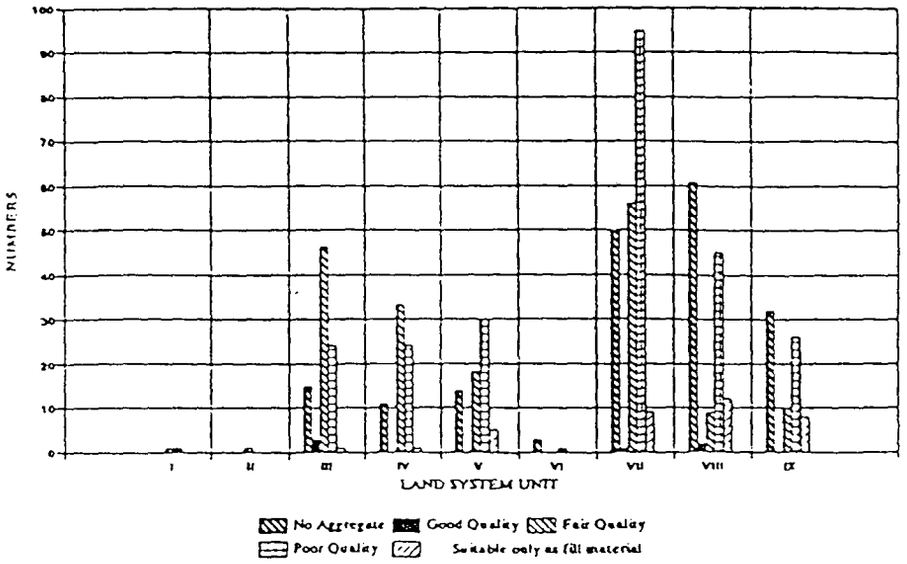
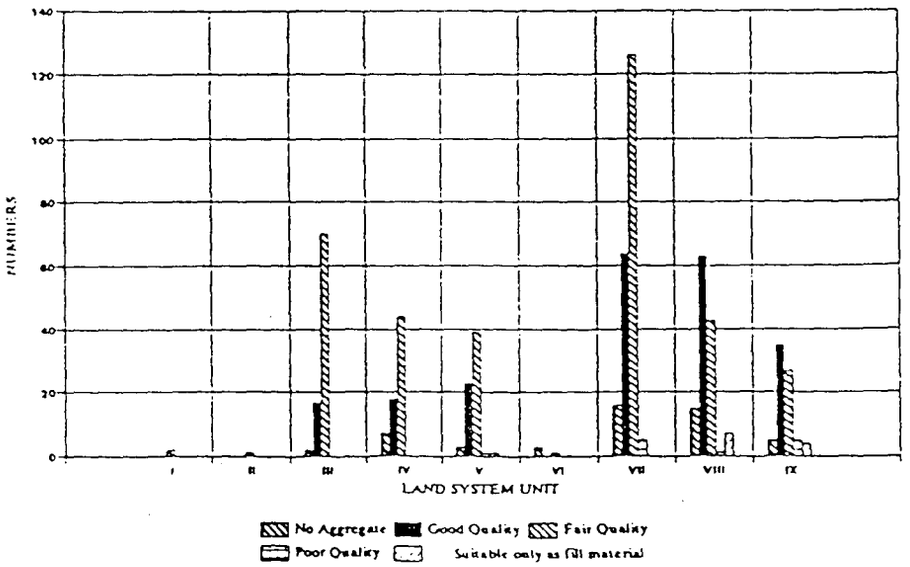


FIGURE 3 POTENTIAL QUALITY OF SOURCES IN W. JAVA TERRAIN PROVINCES

FINE AGGREGATE POTENTIAL



5.2 The Use of Marginal Materials in Pavements

There are areas in Indonesia, for example, parts of Kalimantan, where there is an apparent lack of aggregate sources capable of providing an adequate quality of material to meet existing road design specifications. The development of design strategies to counter this problem is an obvious field of research that could link two of the current TARP project areas, Geotechnics and Pavements.

Ideally research in this field should proceed on two fronts: the detailed examination of materials in these areas; and the development of pavement specifications to try and accommodate the available materials. In other words, given the defined performance of certain materials, is it possible to derive a road pavement design to utilise them ?

Apart from ASBUTON, which has already received considerable attention, some other work has already been done in this field: in the utilisation of laterite gravel as an asphalt aggregate and in the examination of the potential uses of burnt shale in road construction.

5.3 Embankment Fill Materials

At present the NRMI is not concerned with materials whose primary use is embankment fill. However, as the Indonesian road network is developed with increased attention being paid to geometry there will be a corresponding increasing amount of embankment earthworks. For example, the preliminary earthwork designs for the proposed Cikampek to Padalarang Toll Road indicated that some 29 embankments with maximum heights of over 15m, with 10 being over 25m, would be required.

In order to be cost effective the material to build earthworks should come from reasonably close to the site. However one of the problems is that many Indonesian borrow materials, derived as they are by tropical weathering processes, have geotechnical properties different from those found in Europe or America where most current earthwork specifications originated.

Ideal opportunities may exist to undertake practical research projects on the placement and performance of fill materials in conjunction with projects such as the CPTR where materials are likely to be used that do not fall within AASHTO or BS standard specifications. The objective of the above research should be a clearer definition of the useability of tropically weathered soils as fill materials.

A related topic of research, which has already received attention at IRE, is the suitability of groups of fill materials for stabilisation by either lime, cement or by mechanical means. The systematic collation of this existing information would be a first step in the setting-up of a readily available database of information.

5.4 Environmental Impact

The development of quarries, either hard rock or sand and gravel, can have a significantly detrimental effect on the adjacent environment. Table 15 lists some of these effects together with some of the principal causes.

TABLE 15 ENVIRONMENTAL IMPACT OF QUARRY DEVELOPMENT

ACTIVITIES	PRINCIPAL IMPACTS
Site Clearance/building	4, 5, 8
Haul/access roads	1, 2, 7
Blasting	2, 3, 7
Dredging (Pasir Sedot)	4, 5, 6
Mechanical excavation	1, 2, 4
Dams/sediment traps	4, 5, 7
Spoil disposal	4, 5, 6
Aggregate processing	1, 2, 4
Storage	4, 7
Effluent disposal	4, 7, 8
Exhaust fumes	1, 7, 8
Inadequate reinstatement	5, 6, 7
Accidents	7,

Notes

1 = Air pollution (including dust)	2 = Noise
3 = Vibration	4 = Surface water pollution
5 = Ground water pollution	6 = Soil erosion/instability
7 = Human life quality	8 = Animal/plant life

Although the current NRMI does record some information with respect to environmental impact this is done on purely subjective basis with the objective of indicating general areas of concern. It should be possible, after suitable methodology research, to extend this initial step into a more systematic recording of impact factors such as noise, dust and water pollution.

IRE is already undertaking impact research projects in line with the Indonesian Government's commitment to environment protection and the implementation of the AMDAL and ANDAL programmes. This IRE research could be progressed in parallel with materials sources exploration, assessment and development projects. Separate environment files could be set up within the NRMI to hold and disseminate relevant data on dust, noise and groundwater pollution. In the case of key quarries the extended NRMI could provide the basis for the recording of their environmental impact from initial development through to final reinstatement.

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