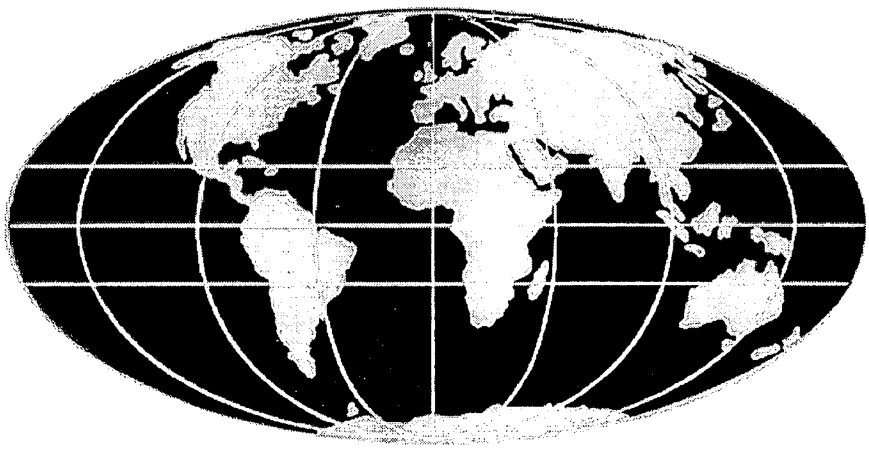
TRANSPORT RESEARCH LABORATORY

DFID Department For International Development

TITLE: The development and value of a construction material information system

by: M E Woodbridge



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PA3285/97

PA3285/97 WOODBRIDGE, M E (1997). **The development and value of a construction material information system.** *Annual Roads Convention on Road Transport: The Key to Development, Dar es Salaam, 24 - 26 September 1997.*

THE DEVELOPMENT AND VALUE OF A CONSTRUCTION MATERIAL INFORMATION SYSTEM

by

M E Woodbridge*

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ABSTRACT

The aggregates business significantly influences the economy and the environment and it is in the interests of everybody that cost effective utilisation of aggregates occurs.

The paper describes the creation of a materials information system in Indonesia. The diverse geographical nature of the country posed special problems in ensuring that a system useful to both central Government and the local provincial engineers was devised. However, the results of the initial research were successful because the Indonesian Department of Transport commissioned the local engineers' offices to carry out their own surveys. Later work was focused in coordinating these surveys. Training courses were held to enable the engineers to carry out their own surveys and process the data using a database software package. The training courses were very successful because the performance in terms of quality and quantity of data improved but there is still scope to improve the utilisation of the system by potential users. The package is to be linked with the Integrated Road Management System in Indonesia which may assist in this respect.

When properly installed with accurate data the information system has many benefits. Data is available in a single location and in a compact, standard format. The system is simple to understand and provides the basic information required by highway engineers. The database can be manipulated to provide answers to specific enquiries. The data can be updated when necessary without problems and can be used, in conjunction with terrain classification and Geographic Information Systems packages (such as MapInfo) to indicate potential new material sources. Costs of installing and maintaining the system are not high. In short, it is an improvement on the status quo.

1 INTRODUCTION

In the West, aggregate consumption is currently about 5 tonnes per person per year. In developing countries the figure is less, possibly between 1 and 2 tonnes per person. For Tanzania with an estimated population of 30 million an aggregate consumption between 30 and 60 million tonnes annually is indicated. The location, exploitation and movement of large tonnages of stone has a considerable impact on the economy and environment.

Construction aggregates are of low value and most of their cost to the consumer is for transport from the source to the point of use. Aggregate prices in the UK average around £6 per tonne, whilst haulage is of the order of £0.1 per tonne per km. It is thus advisable to locate quarries as close as possible to the construction site but this is not always feasible and depends on geological conditions. Before commencing any construction project, surveys are carried out to locate raw materials. A review of the records is generally undertaken before embarking on field surveys but such records are often either dispersed, out of date or of uncertain reliability. Obtaining good records is costly because it requires professional expertise.

With modern computer technology it has become possible to store any information systematically and compactly. The information is capable of being analysed according to specific needs and the results can be produced and distributed effectively. Spreadsheet or database software systems can be used but databases are more efficient at storing and manipulating large amounts of data. Nowadays the two are interchangeable. If this information were available in one central locality it would facilitate cost effective planning of road construction and maintenance and enable better management of existing natural resources.

This paper describes the research undertaken to create an information system in Indonesia. The research was co-funded by the International Bank for Reconstruction and Development (IBRD) and the Department for International Development (DfID) and carried out by staff of the Transport Research Laboratory (TRL) of the United Kingdom who collaborated with a sister organisation in Indonesia, the Institute of Road Engineering (IRE). Similar work is also in progress in some of the Southern African Development Community (SADC) countries.

2 BACKGROUND

Indonesia is divided into 27 provinces, including the capital Jakarta, spread over a vast area of land and sea far exceeding that of the USA, see Fig 1. It is a country with an estimated population of 200 million, with diverse ethnic groups and languages, although there is an official language spoken throughout the archipelago. Central Government is located in Jakarta, a megopolis of 12 million people on the comparatively small island of Java, which has 7% of the land area of Indonesia supporting 60% of the total population. Official policy is to encourage emigration to the eastern provinces which are relatively underpopulated. There is thus a programme for the construction of many new or upgraded roads in the eastern provinces. Apart from this, however, there is a need to maintain and, from time to time, rehabilitate the existing road network and provide the resources for an expanding motorway system to alleviate traffic congestion on Java.

The Indonesian Government recognised the worth of a working materials information system to assist both the central planning department and the provincial engineering offices. Quarrying activities are haphazard and most are unrecorded: also, although regulations exist they are often not enforced. By contrast, in the developed world quarrying operations are now carefully regulated. Quarry output is controlled, reserves are measured and future development programmes are required by law. Safety regulations are strictly enforced. In this way, usage trends and the effects of environmental impact can be known in advance, and planning facilitated.

3 BENEFITS AND COSTS OF AN INFORMATION SYSTEM

For road construction the location of suitable raw materials has generally been regarded as a specific task and costed separately for each project. Because of the unavailability of good information and the uncertainty of locating suitable raw materials close to the point of use, contractors usually quote a premium price for the construction aggregates. However, if an accurate, concise and easy-to-use inventory system of material sources were available it would greatly facilitate the planning and costing of construction projects. Materials appropriate to the type of construction planned could be more easily selected and, conversely, shortages identified. The data would be available in a consistent format and could be updated at suitable intervals. In the end, the material supply costs would be better forecasted.

The costs of installing and maintaining an up-to-date database are not high compared to the potential benefits. One field of three persons should be able to classify two deposits per working day. Laboratory facilities are required to carry out testing but these are presumably already available. A computer specialist plus an assistant are required for data processing. The surveys could commence with a review of the existing data; following this stage the identification of materials for current road projects could be undertaken. The data should be updated at appropriate intervals according to the need.

4 OBJECTIVES

The overall objective in Indonesia was to determine the distribution, quality and quantity of construction materials. However, for a project of this scope, there were different objectives for each participating organisation, see Table 1.

Table 1 : Project Objectives for each participating organisation

Organisation	Objectives
Ind Dep of Transport	Obtain data on the location, properties and cost of road materials; identify shortages
IRE	Develop the technical capability of staff; develop the methodology to collect & process materials data, develop expertise to locate new material sources
TRL/ODA	Develop methodologies transferable to other developing countries
IBRD	Obtain better information for assessment of road management schemes

These differences influenced the database design. For the local engineers a simple spreadsheet would probably have been adequate but for central planning and research a more complex database was required and this was ultimately chosen. The overall concept had to embrace all needs for the project to be sustainable.

5 PROJECT DESIGN

There have been three phases of development of the materials information system in Indonesia. The first two phases involved the initial decisions regarding the list of data to be collected and the software system required to process it. A database system was selected because the amount of data required were very large. Three database systems were worked out: one simple one for entering reconnaissance and/or existing data, with approximately 60 data fields in two database files: a much more complex one containing nearly 500 fields in 20 database files and a third system for detailed pit and borehole information. All systems were linked via common data fields.

With the benefit of hindsight the systems initially developed should have been more user friendly. However, it was not until the third phase, when the Department of Transport began to do its own surveys via the offices of the local engineers, that it was realised that the initial systems developed for the IRE geologists and engineers were too complicated for the local engineers. A simpler standard field data collection form had to be devised, an appropriate software system developed, training courses given to the local engineers in all aspects of the work including the laboratory engineering testing of the samples, and periodic vetting of the performance of the provincial teams carried out. No aspect of the work could be taken for granted and, clearly, it was essential to underline the importance of obtaining good quality data for the system to have any future credibility.

6 RESULTS

6.1 Field Form and Fieldwork

The field data collection form, agreed with IRE engineering staff, is presented in Figure 2. Properly completed, it provides the basic data of raw material deposits, whether they are unconsolidated materials from rivers, soil/surface weathered rock, or crushed hard rock from quarries. The form is easy to understand by non-geologists: it is divided into several categories with many items. If an item consists of a series of options, the list of options is displayed on the field sheet. The data required is arranged in the order that the investigators might collect it. In other words they would seek information concerning the location of the deposit first, followed by the general environment or setting of the deposit, followed by details concerning the material itself, and so on. A list of possible laboratory tests is given: the choice of which tests are necessary are for the investigators to decide. The laboratory results would have to be entered on the form later. The form presented is tailored for Indonesian conditions but could be adapted for other countries without difficulty.

Concerning the field work, a training course to explain and demonstrate the basic principles is essential, especially if the personnel involved are not trained geologists. There are three topics of special importance:

- how to determine the strategy and tactics of proceeding with a survey in a particular area, ie which quarries to survey and in what order? This has caused difficulty, but reference to the national/local road building plan primarily, followed by the need to investigate the main quarries in the major towns, would have top priority.
- how to determine quarry location accurately on a map? Most local engineers found this a difficult task and maps in Indonesia are not easy to obtain. However, it is of great importance, especially if the project is expanded at a later stage with GIS software where accurate coordinates are necessary. To resolve the problem of map location the purchase of Geographic Positioning Systems, a hand-held apparatus which is relatively inexpensive to buy and maintain (about $1000 when new for a modest model), easy to use and sufficiently accurate for the purpose, was recommended.
- how to collect representative samples from a deposit for laboratory testing? This is not necessarily a simple task, especially from soft surface deposits, but the implications are very important.
- the standardisation of laboratory testing throughout Indonesia

6.2 Computer Work

The following describes the software developed for Indonesia but alternative arrangements can be made elsewhere.

The field and laboratory data is inputted into a personal computer using an adapted version of a database program, in this case Foxpro 2.6 for Windows. Every province was provided with a copy of the software. The program is suitable only for 386-DX computers or better, having a minimum of 8 Mbyte RAM and runs on Windows 3.1 or 3.11. Most provinces had computers of this standard but for those who did not, a DOS version was provided. The software is contained on three standard diskettes and is easy to install. On opening the program, the user is presented with a series of three screens similar in appearance to the field data collection form. New data can be entered or existing data browsed (looked at) or changed. The software package has an advantage over the standard Foxpro software in that the data fields cannot be altered, thus ensuring standardisation in all provinces. It also has the capability to produce a standard report, which basically is a print-out of the data shown on the screen. Whilst this may be suitable for the individual provinces, a more flexible system may be preferred for the central office, or for research purposes. This can be produced in a standard manner from the database software coupled to a specialist software report writing package such as Report Writer, version 6.5 for Windows. This method has the advantage that only the data required for the particular enquiry can be selected. Alternatively, and this may be more attractive for many users, the data may be down loaded to a spreadsheet program for further processing.

In Indonesia it is planned that each province sends a copy of their completed diskette to IRE at the end of each fiscal year. All these data are then added to the master database, which is kept at IRE. Enquiries from the Department of Transport are addressed through this database.

7 PROGRESS

The Indonesian Department of Transport commenced their own data collection in the 1994/5 fiscal year. The project was intended to run five years with a total investment of about $500,000 per year, although a large percentage of this is required for administrative and other costs. Until the third aid project started in August 1995 there had been no assessment of performance of the provincial survey teams, which was not good. Training courses were held in June/July 1996 and Table 2 gives an indication in the improvement in performance as judged from several factors. These factors were the quality of the written report and number of deposits assessed, the results of random field checking of selected provincial teams, the assessment of their computer skills and condition of the computers and the condition of the laboratories.

Table 2: Indonesia: Evaluation of Provincial Survey Teams' Performance in Materials Information Project

	1994/5 (25 provinces)					1995/6 (26 provinces)					1996/7 (15 provinces)				
Total no of deposits assessed	423					459					359				
Performance Rating*	1	2	3	4	0	1	2	3	4	0	1	2	3	4.	0
Number in category	3	9	9	1	3	4	14	6	1	1	12	3	0	0	0

*Performance Rating: 1, Good; 2, Acceptable; 3, Requires some improvement; 4, Requires much improvement; 0, No report supplied.

8 POTENTIAL USES OF MATERIAL INFORMATION

There are many potential uses and markets for the materials information system. In Indonesia at least the full potential of the system still needs to be realised. In Section 3 of this paper the benefits were outlined; the potential uses can be summarised as follows:

- to use as a databank for Government planning/consultant/contractor
- to make resources maps of a region
- to identify new sources of materials (in conjunction with terrain maps)
- to make land zoning maps

All potential uses would benefit by the incorporation of software systems linking text and numerical data with spatial data in the form of maps. Geographic Information Systems software, such as MapInfo, can perform this capability.

Ultimately, it should be possible to develop electronic resources maps which would clearly have a great advantage over lists of deposits which require additional processing to interpret.

An example of the uses outlined above is provided by Bali. Although a province of Indonesia, Bali has a higher profile and distinctive problems caused by the need to reconcile the different activities of its population. Fig. 3 presents the current (incomplete) state of the information system for Bali: selected data have been reproduced by the Report Writer software. They indicate that all of the construction materials utilised at the moment are alluvial gravels and sands. Sources of hard rock aggregate, more suitable for some uses such as unbound road bases, need to be identified. Fig. 4 shows the conflicting nature of all these activities on the land space available on Bali and indicates the advantages of having a zoning map of the area.

9. CONCLUSIONS

1. The location, exploitation and movement of construction materials is a large undertaking requiring considerable effort and having a significant effect on the economy and the environment. Making available and maintaining accurate records of these materials is a worthwhile task and facilitates project planning.

2. The development of a computer database system to store and process quarry records is described. Key elements of the system are that it should be straightforward and available to a large number of users. An integrated training scheme covering all aspects of the data collection and processing is essential. The design of a simple field form and accurate collection of field data are fundamental aspects of the system.

3. The benefit of a comprehensive database system is that it promotes cost effective utilisation of construction materials. Data only has to be entered once and can be updated: are available in a standard format: materials appropriate to the specific needs of a project can easily be identified: and the existence of potential new sources indicated.

4. The costs of installing and maintaining an information system are not high compared to the potential benefits.

5. The system can be made more user-friendly by combining the numerical data and maps via Geographic Information Systems software packages.

6. For roads, the integration of the materials information system and the management planning system is an important step facilitating more efficient development of the country's roads.

ACKNOWLEDGEMENTS

The research was undertaken in collaboration with staff from the Indonesian Institute of Road Engineering, part of the Agency for Research and Development of the Department of Transport, all to whom thanks are due. The staff of the local engineers' offices also provided essential assistance and cooperation in the management of the project.

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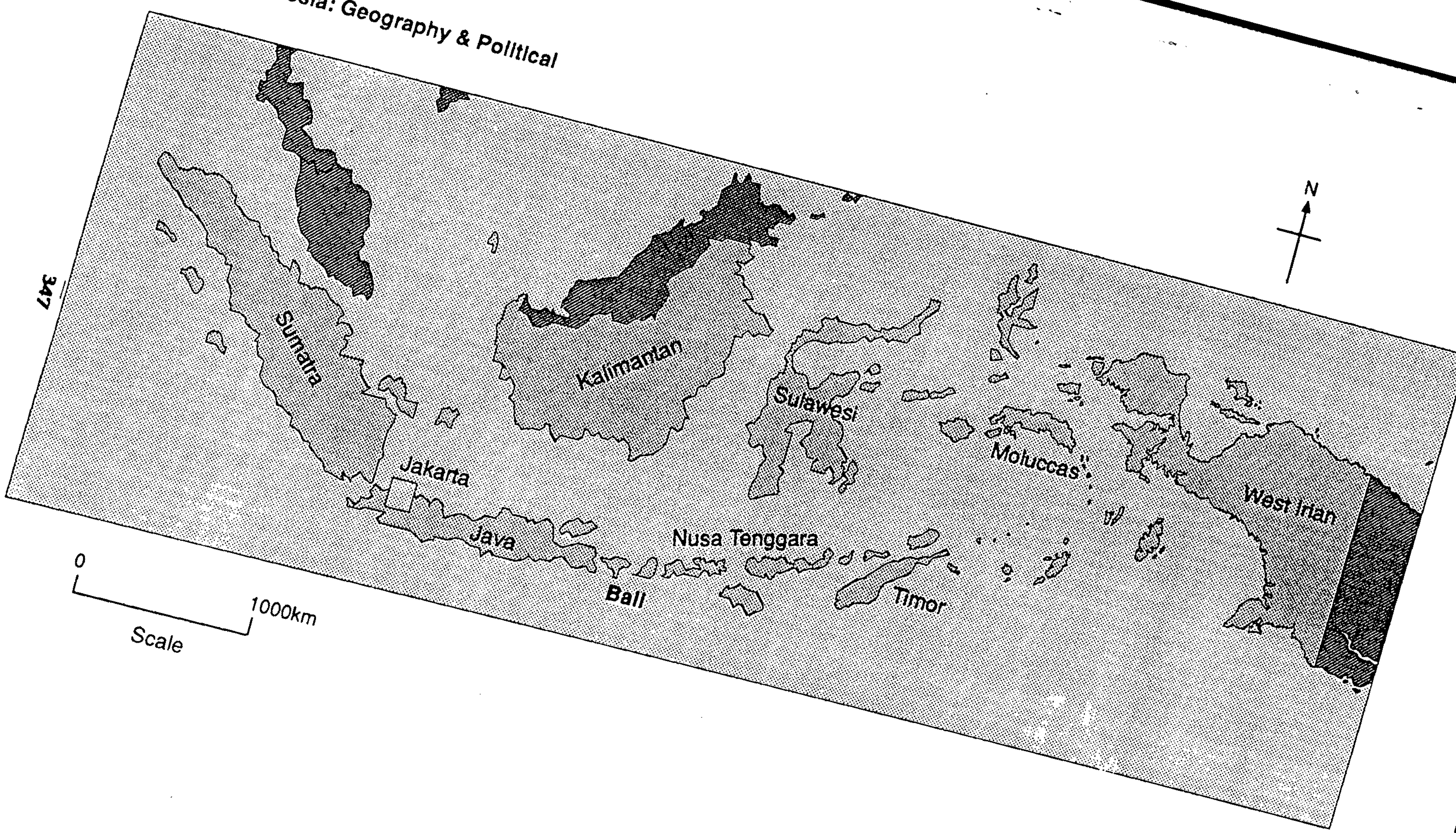
Fig. 1 Indonesia: Geography & Political



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CONSTRUCTION MATERIALS INVENTORY: FIELD FORM

LOCATION

1 Location No

2 Province

3 District

4 Subdistrict

5 Desa

6 Village

7 River

8 Road from

10 Road No

9 Road to

11 Road Status
1. National
2. Provincial
3. District
4. Village

12 Kms from (8)

13 Road Condition
1. Asphalt
2. Gravel
3. Earth

14 Access road distnce

15 Access road condition
1. Asphalt
2. Gravel
3. Earth

16 Coordinates E N

17 Ownership
1. Private
2. Concession

18 Operating status
1. Fully operational
2. Partially operational
3. Not operational
4. Under development

19Operating method
1. Manual
2. Mobile plant

20 Utilities available
1. No utilities
2. Electric power
3. Water
4. Water & electricity

ENVIRONMENT

1 Geomorphology
1. River
2. Coastal
3. Valley side
4. Hill
5. Mountain
6. Plain

2 Land Use

0. None
1. Housing
2. Industrial
3. Plantation
4. Agriculture
5. Forestry
6. Mining
7. Other

3 Envrnmtal Impact

0. None
1. Village
2. Industrial
3. Plantation
4. Agriculture
5. Forestry
6. River
7. Tourism

4 Quarry Restraints

0. None
1. Housing/buildings
2. Flooding
3. Environmental impact
4. Physical

QUARRY MATERIAL DATA

1 Physical State
1.
2.

1. Loose
2. Massive
3. 'Compact'

2 Material Type
1.
2.

1. Sand & Gravel
2. Rock
3. Conglomerate/Breccia
4. Soil

3 Material definition
1.
2.

1. Alluvium, Terrace deposit
2. Andesite,Granite,Diorite,Metamorphic
3. Conglomerate, Breccia
4. Limestone, sandstone, shale

Reserve estimate, m3,
1.
2.

1. < 10.000
2. 10.000-25.000
3. 25.000-50.000
4. 50.000-100.000
5. 100.000-250.000
6. 250.000-500.000
7. 500.000-1.000.000
8. 1.000.000-2.500.000
9. > 2.500.000

5 Field estimate of size percentages (*for alluvium/terrace*)

(>200mm) Boulder 1. 2.

(76-200mm) Cobble 1. 2.

(2-76mm) Gravel 1. 2.

(0.06-2mm) Sand 1. 2.

(<0.06mm) Fines 1. 2.

6 Overburden Type
1.
2.

1. None
2. Loose
3. Mixed loose & hard
4. Compact

7 Overburden Thickness
1.
2.

1. < 1m
2. 1 - 2m
3. 2 - 4m
4. > 4m

8 Material Use
1.
2.

1. Surface dressing
2. Asphalt aggregate
3. Roadbase
4. Subbase
5. Concrete aggregate
6. Fill
7. Housing & others

QUARRY PRODUCT DATA

1 Type
1.
2.
3.
4.

2 Size, Max & Min (mm)
1.
2.
3.
4.

3 Production rate (m3/minggu)
1.
2.
3.
4.

4 Price (Rp/m3)
1.
2.
3.
4.

SAMPLE DESCRIPTION AND LABORATORY TESTS REQUIRED

1 Material Type 1. ______ 2. ______

1. Loose
2. Massive
3. Compact

2 Sample derivation 1. ______ 2. ______

1. Test pit
2. Borehole
3. Surface
4. Side section
5. Hand

3 Sample Size (kg) 1. ______ 2. ______

4 Laboratory Tests required

Water Absorption		Elongation	
Specific Gravity (bulk)		Flakiness	
Specific Gravity (ssd)		Stripping	
Specific Gravity (app)		Sulphate Soundness	
Los Angeles Abrasion		Atterberg Limits	
10% Fines (dry)		Compaction	
10% Fines (soaked)		Grading	
Impact Value (dry)		CBR	
Impact Value (soaked)		Swell	
Polished Stone Value		Organic Content	

REMARKS

1 Photo Nos ______

2 Survey team ______

3 Survey date ______

Notes

LABORATORY TEST RESULTS

Date	

AGGREGATE TEST RESULTS

	SAMPLE 1	SAMPLE 2
Water Absorption, %		
Specific Gravity (dry), %		
Specific Gravity (sat sur dry), %		
Specific Gravity (apparent), %		
Los Angeles Abrasion, %		
10% Fines Value, (dry),kN		
10% Fines Value (soaked), kN		
Impact Value, (dry), %		
Impact Value, (soaked), %		
Elongation, %		
Stripping,%		
Flakiness, %		
Sulphate Soundness, %		
Polished Stone Value, %		

SOIL TEST RESULTS

COMPACTION

	SAMPLE 1	SAMPLE 2
Compaction type		
Maximum dry density, kg/cc		
Optimum moisture content,		
CBR at Optimum moisture content %		
CBR (at OMC) after 4 days soaking, %		
Swell, %		
Organic Content, %		

ATTERBERG LIMITS

	SAMPLE 1	SAMPLE 2
Liquid Limit (LL)		
Plastic Limit (PL)		
Plasticity Index (PI=LL-PL)		

GRADING

	SAMPLE 1	SAMPLE 2
Passing 2.5" sieve		
Passing 1.5' sieve		
Passing 3/4" sieve		
Passing 3/8" sieve		
Passing No 4 sieve		
Passing No 8 sieve		
Passing No 16 sieve		
Passing No 30		
Passing No 50 sieve		
Passing No 100 sieve		
Passing No 200 sieve		

CONSTRUCTION MATERIALS INFORMATION SYSTEM

PROVINCE : BALI

QUARRY DATA

PROV.NO : 40

LOC. NO	LOCATION										COORDINATE		MATERIAL			DATE
	DISTRIC	SUBDISTRIC	DESA	KAMPUNG	ROAD FROM	ROAD TO	LINK	CLASS	CHAIN.	ACCES-Dist	MAP-E	MAP-N	TYPE	DEFIN	RESV	
1.00	JEMBRANA	PEKUTATAN	PULUKAN	BANJAR PASAR	PULUKAN	NEGARA	3	1	70.0	0.30	260000	9069200	2	CAMPURAN	7	15/11/95
2.00	JEMBRANA	PEKUTATAN	MEDEWI	BANJAR PERSIN	PULUKAN	NEGARA	3	1	73.0	0.15	258650	9068925	2	CAMPURAN	5	15/11/95
3.00	JEMBRANA	PEKUTATAN	MEDEWI	DUSUN LOLOAN	PULUKAN	NEGARA	3	1	72.4	1.40	258250	9070200	2	CAMPURAN	7	15/11/95
4.00	JEMBRANA	MENDOYO	TIBU SAMBI	DUSUN TIBU SA	TEGAK GEDE	BANJAR KALERAN	40	3	80.7	0.00	255000	9072350	2	CAMPURAN	5	15/11/95
5.00	JEMBRANA	MENDOYO	NUSA MARA	NUSA MARA	TEGAK GEDE	BANJAR KALERAN	40	3	80.7	1.60	254500	9074350	2	CAMPURAN	2	17/11/95
6.00	JEMBRANA	MENDOYO	YEH EMBANG KANGIN	YEH SUMBUL	PULUKAN	NEGARA	3	1	76.3	0.35	255950	9071250	2	CAMPURAN	3	17/11/95
7.00	JEMBRANA	MENDOYO	TEGAL CANGKRING	BILUK POH	BILUK POH	BANJAR SEMBUNG	73	3	86.9	0.25	247000	9073000	2	CAMPURAN	4	18/11/95
8.00	JEMBRANA	NEGARA	BATU AGUNG	BATU AGUNG	BATU AGUNG	PANCA SEMING	49	3	92.8	1.60	240500	9075250	2	CAMPURAN	2	18/11/95
9.00	JEMBRANA	NEGARA	BATU AGUNG	BANJAR TAMAN	BATU AGUNG	PALUNGKAN BATU	50	3	94.6	0.00	240500	9076000	2	CAMPURAN	2	18/11/95
10.00	JEMBRANA	MELAYA	KALIAKAH	PANGKUNG BULU	PANGKUNG BULUH	BANYUBIRU	146	3	103.2	0.25	0	0	2	CAMPURAN	4	18/11/95
11.00	JEMBRANA	MELAYA	MANISTUTU	TUNAS MAKAR	PANGKUNG BULUH	MANISTUTU	15	3	101.6	0.30	0	0	2	CAMPURAN	3	18/11/95
12.00	JEMBRANA	MELAYA	CANDI KUSUMA	CANDI KUSUMA	CANDI KUSUMA	SIMPANG TUWED	59	3	109.4	1.00	0	0	2	CAMPURAN	1	18/11/95
13.00	KARANGASEM	KUBU	BONYOH	BONYOH	AMLAPURA	KUBUTAMBAHAN	33	2	78.0	7.30	334900	9091000	2	CAMPURAN	3	18/4/96
14.00	KARANGASEM	KUBU	SUKADANA	SEKARSARI	AMLAPURA	KUBUTAMBAHAN	33	2	78.0	6.80	334900	9091000	2	CAMPURAN	4	21/4/96
15.00	KARANGASEM	KUBU	TIANYUR TIMUR	DARMAWINANGUN	AMLAPURA	KUBUTAMBAHAN	33	2	78.0	0.00	335700	9092850	2	CAMPURAN	5	21/4/96
16.00	KARANGASEM	KUBU	TIANYUR TIMUR	DARMAWINANGAN	AMLAPURA	KUBUTAMBAHAN	33	2	78.0	0.20	338500	9091600	2	CAMPURAN	4	21/4/96
17.00	KARANGASEM	KUBU	BATURINGGIT	SEKARSARI	AMLAPURA	KUBUTAMBAHAN	33	2	78.0	0.10	341500	9088300	2	CAMPURAN	5	21/4/96
18.00	KARANGASEM	KUBU	TULAMBAN	MUNTIG	AMLAPURA	KUBUTAMBAHAN	33	2	78.0	1.60	346300	9082000	2	CAMPURAN	4	21/4/96
19.00	KARANGASEM	BEBANDEM	JUNGUTAN	YEH BUNGA	AMLAPURA	RENDANG	53	2	74.6	7.60	338960	9068800	2	CAMPURAN	3	21/4/96

CONSTRUCTION MATERIALS INFORMATION SYSTEM

PROVINCE : BALI

LABORATORY DATA

PROV.NO : 40

LOC. NO	LOCATION		MATERIAL	PHYSICAL-MECHANICAL							SIEVE ANALYSIS, % passing sieve size,mm										DATE
	DISTRIC	DESA	TYPE	W-ABS	LAA	AIV-Dry	Stripping	Soundness	LL	PL	38.10	19.00	9.50	4.75	2.38	1.18	0.60	0.30	0.15	0.075	
1.00	JEMBRANA	PULUKAN	CAMPURAN	2.04	17.10	0.00	0.00	0.00			59.60	29.06	20.74	16.57	12.07	7.01	2.48	0.69	0.06	0.02	21/11/95
2.00	JEMBRANA	MEDEWI	CAMPURAN	2.02	18.60	0.00	0.00	0.00			86.14	54.91	41.15	33.28	28.99	19.70	10.41	3.15	0.51	0.11	21/11/95
3.00	JEMBRANA	MEDEWI	CAMPURAN	2.58	18.20	0.00	0.00	0.00			86.81	52.52	37.90	30.44	26.01	18.58	9.91	2.69	0.50	0.18	21/11/95
4.00	JEMBRANA	TIBU SAMBI	CAMPURAN	2.67	20.60	0.00	0.00	0.00			75.11	45.20	33.10	28.60	18.40	13.50	10.11	5.90	2.10	1.79	21/11/95
5.00	JEMBRANA	NUSA MARA	CAMPURAN	2.60	20.40	0.00	0.00	0.00			70.48	40.30	31.50	25.76	16.40	11.20	8.28	5.40	2.20	1.30	21/11/95
6.00	JEMBRANA	YEH EMBANG KANGIN	CAMPURAN	2.46	20.50	0.00	0.00	0.00			60.38	31.19	26.75	20.25	15.24	12.11	9.55	5.93	1.88	0.99	21/11/95
7.00	JEMBRANA	TEGAL CANGKRING	CAMPURAN	2.35	18.80	0.00	0.00	0.00			76.22	46.16	35.49	30.32	25.60	21.43	14.90	6.48	3.03	1.92	21/11/95
8.00	JEMBRANA	BATU AGUNG	CAMPURAN	1.93	18.60	0.00	0.00	0.00			58.92	59.54	31.89	28.09	23.38	18.29	10.74	3.38	0.69	0.20	21/11/95
9.00	JEMBRANA	BATU AGUNG	CAMPURAN	2.02	18.30	0.00	0.00	0.00			56.35	35.93	27.78	23.69	18.57	13.23	8.81	3.52	0.68	0.20	21/11/95
10.00	JEMBRANA	KALIAKAH	CAMPURAN	2.56	18.10	0.00	0.00	0.00			57.46	29.88	19.55	13.26	9.07	5.65	3.39	1.41	0.99	0.30	21/11/94
11.00	JEMBRANA	MANISTUTU	CAMPURAN	2.11	18.20	0.00	0.00	0.00			92.05	58.58	38.95	28.25	18.57	11.67	7.26	5.35	2.55	1.50	21/11/95
12.00	JEMBRANA	CANDI KUSUMA	CAMPURAN	1.97	19.00	0.00	0.00	0.00			91.06	75.66	63.48	53.51	43.06	32.25	18.38	5.77	1.30	0.37	21/11/95
13.00	KARANGASEM	BONYOH	CAMPURAN	4.81	29.77																21/4/96
14.00	KARANGASEM	SUKADANA	CAMPURAN	4.58	30.70																21/4/96
15.00	KARANGASEM	TIANYUR TIMUR	CAMPURAN	2.89	29.10																21/4/96
16.00	KARANGASEM	TIANYUR TIMUR	CAMPURAN	4.53	29.00																21/4/96
17.00	KARANGASEM	BATURINGGIT	CAMPURAN	3.51	29.00																21/4/96
18.00	KARANGASEM	TULAMBAN	CAMPURAN	3.65	30.80																21/4/96
19.00	KARANGASEM	JUNGUTAN	CAMPURAN	3.52	27.00																21/4/96

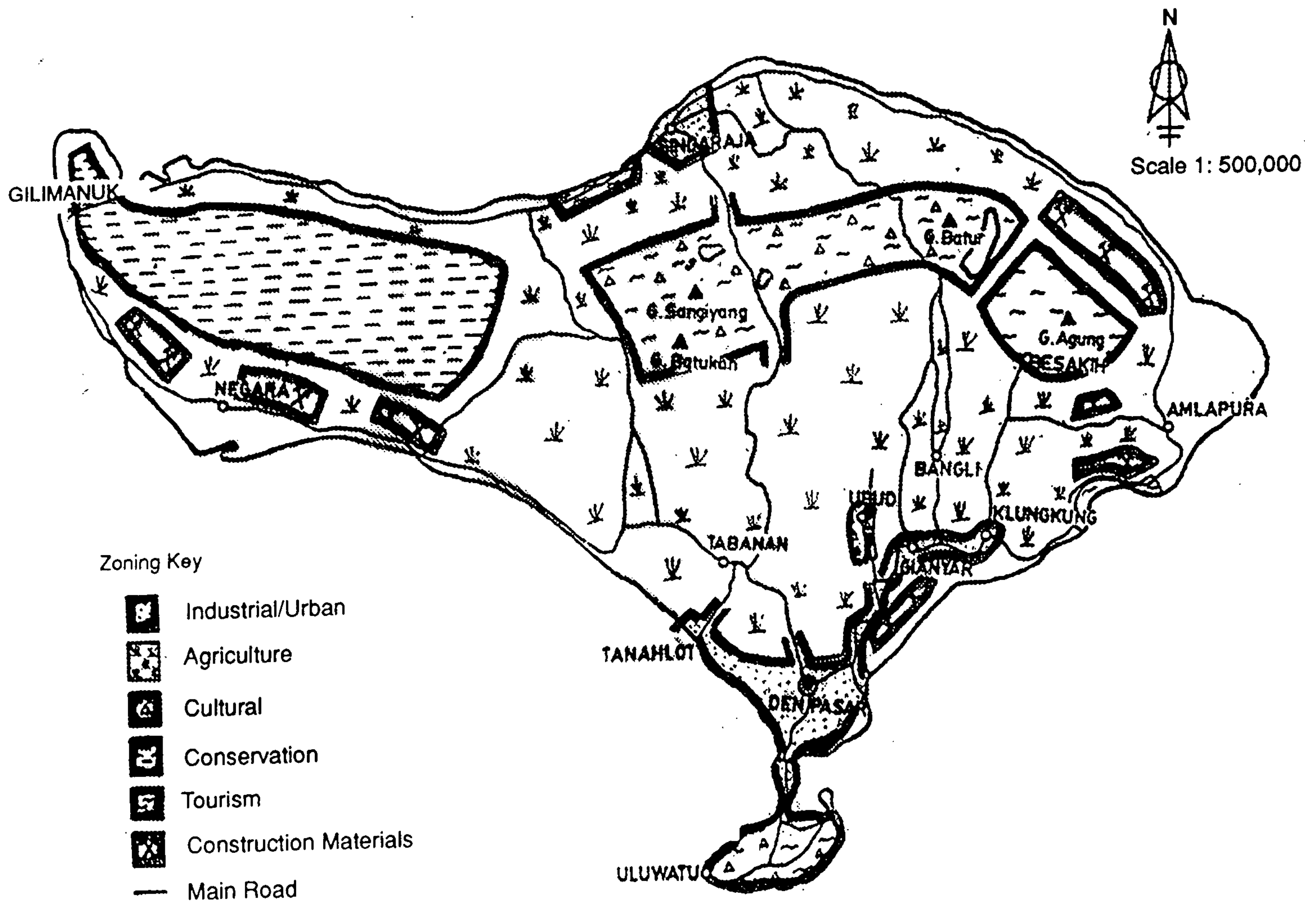

Fig. 4 Bali: Proposed land zoning