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TITLE: The design and use of a road materials inventory

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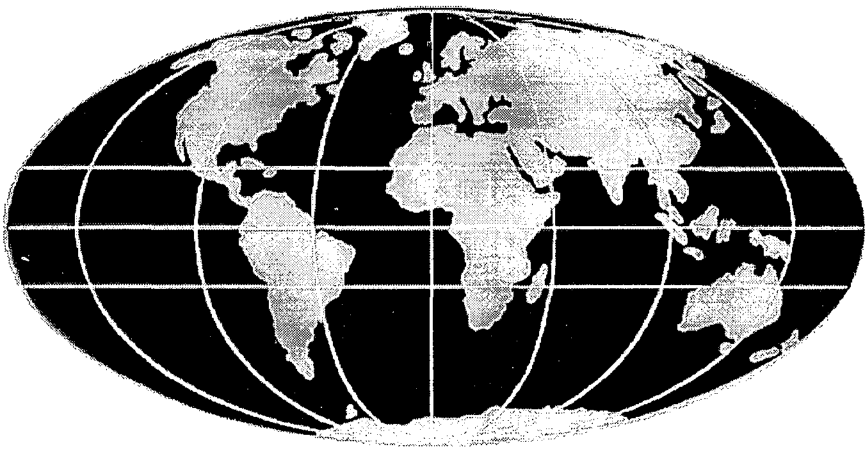

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THE DESIGN AND USE OF A ROAD MATERIALS INVENTORY

BY

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ABSTRACT

Any highway engineering project demands information on the availability, quality and costs of road-making materials. This paper describes a pilot road materials inventory for West Java, which combined a research project to investigate the most efficient techniques to be used with a full survey for one Indonesian province.

A preliminary desk study identified existing sources most of which were visited and classified on site, using special forms designed to provide easy entry of the information into a computer database. Representative samples were taken for testing and recommendations on their potential use similarly codified. All samples were classified according to geology and terrain units.

The paper explains how such a data store can be used for road planning and construction projects, giving examples of data extracted from the computer database in a format suited to a District Engineer. It concludes with a description of how the study could be extended to other areas to produce an integrated national inventory.

INTRODUCTION

1 Accurate project planning depends on having access to reliable information presented in a suitable format. For highway engineering projects the availability and costs of road making materials is one of the required information sets. At the national planning level this may be required to estimate the costs of road building needed to support development projects. At the local planning level the information on materials will be used to prepare feasibility surveys. It may also be used to identify regional problems the solution of which is the development of new quarries or processing plants. At the local level the highway engineer needs to know where to find materials for construction and maintenance works.

2 This wide range of objectives has led to a variety of approaches, ranging from the recording of laboratory test data, through surveys of separate quarries, to resource surveys based on material type or geographic region. In addition to this, the rapid development of computing systems has caused a reappraisal of the implementation of inventories. The original systems were report or card based but in the

1970s there was a move to using computer storage, often using specially written FORTRAN programs. The increase in power of microcomputers has been followed by the development of special database programs, of which the dBASE family is most widely known. The situation now exists whereby a materials inventory can be installed on a personal computer and the project described in this paper was designed to establish the usefulness and limitations of such a system.

BACKGROUND TO PROJECT

3 The Institute of Road Engineering (IRE), which is the road research institute of the Departemen Pekerjaan Umum (DPU) in Indonesia, has been collaborating with the Transport and Road Research Laboratory UK (TRRL) for the past 10 years. As part of this work an IBRD funded training and research programme (TARP) was established in 1988-89. The two main research topics of the TARP were the development of a road materials inventory and investigations of bituminous surfacings. The training objective included both formal instruction and practical counterpart training. The road materials inventory was supervised by an experienced engineering geologist recruited as a materials specialist.

4 The objectives of the Road Material Inventory (RMI) project, as viewed within the context of the TARP as a whole, were perceived to be as follows:-

a) *A training objective* to transfer technical knowledge and practical experience to the relevant IRE professional staff.
b) *A theoretical objective* to develop and examine the validity of a methodology for the assembly of a Road Materials Inventory.
c) *A practical objective*, to assemble a pilot Road Materials Inventory of West Java and part of South Sumatera.

5 This paper describes the creation of the pilot inventory and considers how such a study could be extended on a national scale. The main pilot study was based in the local province of West Java to minimise travel. This was appropriate for the development of the system and made the training and supervision of field teams easier. However it was recognised that it would be necessary to extend the system when used in a different terrain type and so the project was designed to include a preliminary survey of South Sumatera.

6 The West Java RMI embodies the concept that compiling an inventory of material sources and properties provides an effective tool for use by road engineers, planners and researchers. Such an inventory consists of locations recorded as individual sources of material and is not assembled as a resource survey of a particular geographical or geological entity. It may be argued in the Indonesian context that a project such as the RMI provides a starting point for other forms of resource survey.

PROJECT PREPARATION AND PLANNING

7 Following on from the TARP terms of reference a basic project strategy was devised and is summarised in the following five main elements:-

a) *Desk study*. Collection of available data, including maps and information on known source locations. This included preliminary visits to kabupaten (district) offices. Systematic collation of data for a field verification programme of 464 sources.
b) *Field verification*. Systematic collection of data from all identified current sources of aggregate using pro-forma field sheets in conjunction with photographs and sketches. Collection of samples for testing.
c) *Laboratory testing*. Undertaking of a selected range of suitable aggregate index tests on recovered samples.
d) *Database assembly*. Collation and cross-checking of all field and laboratory data. Formation of RMI database system and keyboard entry of validated data. Compilation of maps.
e) *Data dissemination*. Compilation of kabupaten manuals together with relevant guides to their use. Distribution of manuals in conjunction with a provincial seminar held at IRE.

8 This strategy was put into effect utilising engineers and geologists from IRE backed up by the materials specialist with technical computing support from TRRL. The interrelationship of the above stages is illustrated in Figure 1. In developing this strategy a number of constraints, in addition to those embodied in the Project Terms of Reference, had to be taken into consideration:-

a) The training objective of TARP.
b) The 12 month project time scale.
c) The technical experience of the assigned IRE staff.

9 These constraints combined to put the following limitations on the West Java inventory:-

a) Only current sources of aggregate would be considered.
b) The inventory would not include sources to be used primarily as fill material.
c) No subsurface exploration or instrumented survey work was undertaken.
d) As much as possible of the technical work was undertaken by IRE staff.

10 A review of project and likely user requirements led, in the light of previous experience, to the establishment of the following general headings under which field data would be gathered:-

a) Source Locations.
b) Physical Environment.

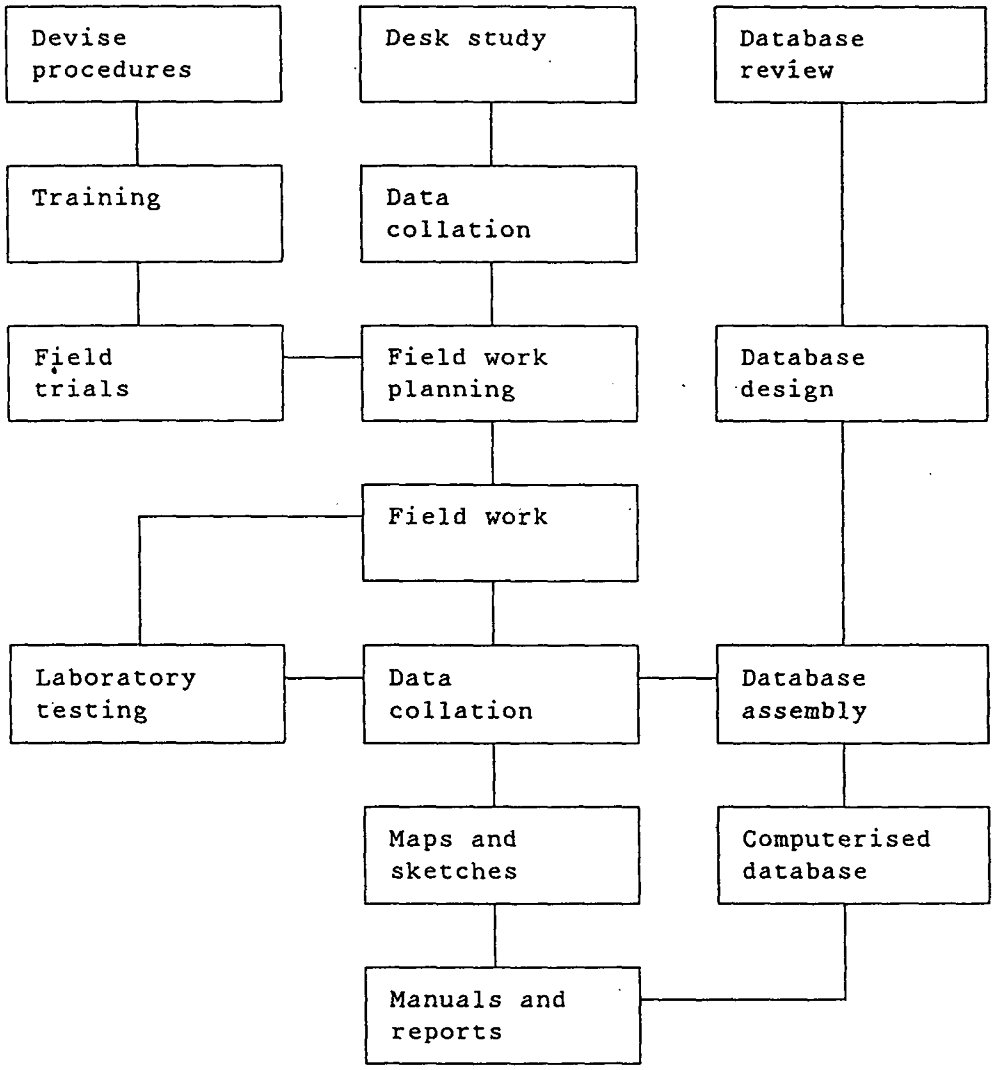

Figure 1 : RMI Activity flow chart

c) Material Quality.
d) Material Quantity.
e) Material Costs.

11 In order to facilitate the collection of the varied and extensive data anticipated under these headings, three standard field forms, Location, Material and Product, were designed such that the majority of information could be entered by choosing answers to questions from lists of options included in a field manual. This purpose written field manual contained relevant definitions, tables and figures for use by the field personnel. Typical field forms used in the field verification are presented as Figures 2 and 3. The separate field forms generally relate to data files whilst the various characteristics on each form relate to data variables.

12 It was planned that this procedure would result in a data gathering programme which would be compatible with the following guidelines:-

a) The collection of relevant information.
b) The collection of the data in a form that reduced operator bias as much as possible.
c) The collection of the data in a format that could be relatively easily transferred to microcomputer spreadsheets and databases.
d) The systematic collection and numbering of samples.

13 Desk study data collection was undertaken principally in Indonesia and consisted of acquiring available data on existing sources and collecting together the necessary geological and topographic maps and air photographs.

14 Towards the end of the desk study period the detailed planning and organisation of the fieldwork phase was given close consideration. This programming took into account the following factors:-

a) The numbers of identified potential sources.
b) The composition of the assigned Road Materials Group.
c) The high priority given to professional training.
d) The limiting time scale.
e) The necessity to do fieldwork in South Sumatera.
f) The lessons learnt from the field trials.

15 This detailed fieldwork planning was done on a kabupaten by kabupaten basis and resulted in the production of a series of monthly programmes that gave the field teams identifiable work targets.

FIELD AND LABORATORY VERIFICATION

16 The adopted strategy required that all identified sources of aggregate in West Java must be visited and verified by field teams. The basic approach to the fieldwork was to use three teams to visit, sample

Figure 2: Typical completed field sheets (1 and 2)

ROAD MATERIALS SURVEY: WEST JAVA. SHEET 1: SOURCE IDENTIFICATION

SOURCE NAME RUPIT SOURCE NUMBER 007/001

A. LOCATION

1. Kabupaten GARUT	2. Kecamatan BUNGBULANG	3. Kampong/Desa CIHIKEU
4. Rd from: CIHIKEU	5. To: BOJONG RANOU	6. Link 43 / 7. Class 3
8. Kilometre 4.9	9. Access Distance 0.2	10. Access Condition 4
11. Map Sheet 4620 IV	12. Map co-ords 0788800 E 9176250 N	

B. OPERATIONAL DETAILS

1. Owner DESA	2. Operating company M	3. Status 2
4. Extraction Methods 4	5. Plant 4	6. Services 0

C. ENVIRONMENT

1. Geology T	2. Geological Map BANDUNG RAYA II	3. Landform 2
4. Hydrology problems Y/N Y	If Yes enter group Nos. 3	

D. SOURCE MATERIALS

1. Materials described on sheet 2 with % : 1 40 2 40 3 20

2. Overburden 3 — 3. Thickness <1 / 1-2m ✓ / 2-4m / >4m / Other

4. Thickness Variation — 5. Contact Dip Angle & Direction

E. USAGE

	1	2	3	4	5
1. Surface Dressing	P	P	–		
2. Asphalt aggregate					
3. Base	A	P	–		
4. Sub-base					
5. Selected fill	P	P	–		

	1	2	3	4	5
6. Common fill			P		
7. Filter			–		
8. Concrete aggregate	P	P	–		
9. Building materials	A	P	P		
10. Other					

F. DEVELOPMENT

Reserves($*10^3M^3$)	<10	10-25	25-50	50-100	100-250	250-500	500-1M	1M-2.5M	>2.5
1. Proven	✓								
2. Potential							✓		

3. Development restraints 2 5 — 4. Face heights 0.5

G. ADDITIONAL INFORMATION

1. Photos 7 — 2. Inspectors TEAM 3 — 3. Date 25.07.88

4. Remarks A.9 : FOOTPATH

ROAD MATERIALS INVENTORY: WEST JAVA SHEET 2: MATERIALS DESCRIPTION

A. IDENTIFICATION

1. Source No. 007/001 — 2. Material No. — 3. Material Type Ba (2)

B. TEXTURE

1. Particle Size Range 1 to 7

2. Grading %: Bldr 40, Cobb 30, Grav 20, Sand 7, Fine 3

3. Shape 3 — 4. Angularity 2 — 5. Surface Texture 3

6. Variability 2: 3, 3: 2, 4: 2, 5: 3

C. MATERIAL PROPERTIES

1. Clast Type a 102, b 101, c 117 — 2. Strength a 13, b 14, c –

3. Plasticity 1 — 4. Density 5 — 5. Deleterious Inclusions 7 : 13% — 6. Porosity 5

7. Variability 2: 3, 3: 2, 4: 3, 5: 3, 6: 3

D. MASS PROPERTIES

1. Strength 6 — 2. Structure 4 — 3. Variability 1: 2

E. BEDROCK GEOLOGY

1. Bedrock type — 2. Texture — 3. Mineralogy — 4. Weathering

5. Deleterious Inclusions — 6. Variability 2, 3, 4

F. BEDROCK STRUCTURES

1. Form — 2. Bedding — 3. Foliation/layering

4. Jointing a, b

G. BEDROCK BEHAVIOUR

1. Strength — 2. Schmidt number — 3. Weakened by soaking

4. Density — 5. Porosity — 6. Variability 1, 2, 3, 4, 5

H. SAMPLING

1. Numbers	2. Type	3. Date	4. Location	5. Representability	6. Comment
007/001/01	3	25.7.88	2	3	BOULDERS
007/001/02	3	25.7.88	2	2	SAND + GRAVEL

I. ADDITIONAL INFORMATION

1. Inspectors TEAM 3 — 2. Date 25.07.88

3. Remarks

Figure 3: Typical completed field sheets (2 and 3)

ROAD MATERIALS INVENTORY: WEST JAVA SHEET 2: MATERIALS DESCRIPTION

A. IDENTIFICATION

1. Source No. 007/001 | 2. Material No. 2 | 3. Material Type Ab (1)

B. TEXTURE

1. Particle Size Range ___ to ___ | 2. Grading x: Bldr | Cobb | Grav | Sand | Fine

3. Shape ___ | 4. Angularity ___ | 5. Surface Texture ___

6. Variability 2 ___ 3 ___ 4 ___ 5 ___

C. MATERIAL PROPERTIES

1. Clast Type a ___ b ___ c ___ | 2. Strength a ___ b ___ c ___

3. Plasticity ___ | 4. Density ___ | 5. Deleterious Inclusions ___ | 6. Porosity ___

7. Variability 2 ___ 3 ___ 4 ___ 5 ___ 6 ___

D. MASS PROPERTIES

1. Strength ___ | 2. Structure ___ | 3. Variability 1 ___

E. BEDROCK GEOLOGY

1. Bedrock type 102 | 2. Texture 2 | 3. Mineralogy 515 | 4. Weathering 2

5. Deleterious Inclusions 2 : 1% | 6. Variability 2: 2, 3: 2, 4: 3

F. BEDROCK STRUCTURES

1. Form / — | 2. Bedding — — | 3. Foliation/layering — —

4. Jointing a 3 b / c / d 3

G. BEDROCK BEHAVIOUR

1. Strength 13 | 2. Schmidt number 54 | 3. Weakened by soaking N

4. Density 5 | 5. Porosity 5 | 6. Variability 1: 2, 2: 2, 3: /, 4: 2, 5: 2

H. SAMPLING

1. Numbers	2. Type	3. Date	4. Location	5. Representability	6. Comment

I. ADDITIONAL INFORMATION

1. Inspectors TEAM 3 | 2. Date 25.07.88

3. Remarks H: NO SAMPLING
F.4: JOINT SPACING VARIABLE 1-3

ROAD MATERIALS INVENTORY: WEST JAVA. SHEET 3: PRODUCT DESCRIPTION

A. IDENTIFICATION									
1. Source Number	007/001				RUPIT				
2. Product Number	1	2	3	4	5	6	7	8	9
3. Material Number	/	/	/						
B. PRODUCT DESCRIPTION 1. Type	3	3	/						
2. Size (max) / Size (min) / Variability	50 / 30 / 3	30 / 20 / 3	40 / 0 / 3						
3. Shape / Variability	3 / 3	3 / 3	5 / 3						
4. Angularity / Variability	4 / 3	4 / 3	2 / 3						
5. Surface texture / Variability	3 / 2	3 / 2	2 / 3						
C. PRODUCT PROPERTIES 1. Strength / Variability	13 / 2	13 / 2	— / —						
2. Density / Variability	5 / 2	5 / 2	— / —						
3. Porosity / Variability	5 / 2	5 / 2	— / —						
D. PRODUCTION 1. Rate / 2. Cost	14 / 4000	7 / 6000	63 / 2000						

E. SAMPLING

1. Numbers	2. Type	3. Date	4. Location	5. Representability	6. Comment

F. ADDITIONAL INFORMATION

1. Inspectors TEAM 3 | 2. DATE 25.07.88

3. Remarks NO SAMPLING

and describe the identified aggregate sources. Each team consisted of a geologist and an engineer together with a driver and a four wheel drive vehicle. In West Java the teams worked in the field on a two weeks on, one week off, basis so that there was always one team in the office and two in the field at any one time.

17 The office team reviewed and collated the work of its previous two field weeks and prepared maps and the detailed programme for the next period.

18 In addition to visiting those sources noted from the desk study data collection, the field teams located and verified all other relevant sources identified from local knowledge. An additional 206 locations were identified in this way. Some overlapping data from existing inventories reduced the net increase to 192 locations, which meant an additional 40% of fieldwork.

19 In order to set limits on the inventory the following criteria were adopted as prerequisites for including sources:-

a) The location had to be a source of fine or coarse aggregate that either had been or was currently operational.
b) The location either had to be an identified DPU source or have reserves in excess of $10,000m^3$.

Adjacent locations that could be considered as a single geological entity were combined into one source. Sources were not divided on the basis of ownership boundaries.

20 At each identified location, after an initial walkover survey, the field teams completed the three field forms, drew relevant site sketches and took photographs of site layouts and key features. Typical completed field forms are presented as Figures 2 and 3.

21 In addition to the field teams there was a management or consultancy team consisting of the materials specialist and the IRE counterpart. Their role was to visit the field teams and advise them on problems, cross check the data collection, advise on day to day planning and generally act as logistic support. This team split its time between office and field.

22 An important role was identified for a liaison engineer between the field teams and the laboratory. This engineer had responsibility for transporting samples back to IRE, registering them and assigning relevant tests. In general he acted as a link between the field teams and the senior laboratory technician. His role also included the monitoring of the progress of the testing programme.

23 The above organisation was drawn up in such a manner that the IRE staff could undertake as much of the project work themselves in terms of planning and achieving team targets. The activities of the

consultancy team ensured that advice and on the job technical advice was readily available.

Table 1
Laboratory testing: RMI West Java

Test Type	No. of Tests
Water absorption	1309
Specific Gravity	1309
Los Angeles Abrasion (LAA)	699
Agg. crushing value (ACV)	364
Agg. impact value (AIV)	739
10% Fines	51
Elongation/flakiness	537
Soundness	38
Agg. stripping	382
Organic classification	453
Point load	67
Grading	786
Density/moisture content	26
CBR	26
Atterberg limits	15

24 The general approach to testing was to assign large numbers of a few standard aggregate index and grading tests, and a more limited number of other tests. This approach has proved successful in supplying statistically viable data on groups of locations defined by material type or terrain. The amount of testing undertaken is summarised in Table 1.

DATABASE ASSEMBLY AND DISSEMINATION

25 The TARP Road Materials Inventory of West Java was assembled at IRE as a database consisting of the following:-

a) Original field and laboratory result sheets.
b) Computer database.
c) Computer database output reports.
d) Field sketches.
e) Kabupaten manuals.
f) Photographs.

26 This database was set up to comply with the following perceived guidelines:-

a) It must contain relevant information.
b) The information should be accurate.
c) Database information should be easily accessible by engineers or planners.

d) Database information should be held on computer hard disk.
e) Hard copy print out of the computer information should be available.
f) The database should be capable of being updated.

27 The variable uses to which a materials inventory may be put requires effective and flexible reporting and data dissemination procedures. The use of a computerised database provides this flexibility which, in the case of the current inventory, has been enhanced by the use of the R&R Relational Report Writer program in conjunction with the dBASE III PLUS system. The data assembly and checking procedures are summarised in Figure 4. The R&R Relational Report Writer program is currently used as the principal means of extracting and reporting on information contained in the RMI database. A number of standard report templates were created for use in the initial reporting phase; subsequently a further suite of templates has been added as aids to research.

28 The interrogation of the database is greatly facilitated by the use of the R&R Relational Report Writer program. In general terms, this program accesses the data files to list sources that comply with conditions imposed by the user. To illustrate the wide range of queries that may be drawn up, some typical examples are listed below:-

a) List all sources in West Java that produce class 1 coarse aggregate.
b) List all sources in Cirebon that are adjacent to road link number 074.
c) List all sources on the Cimanuk river that produce good quality sand with less then 5% fine material.
d) List all good quality bedrock aggregate sources in Bandung with a water absorbtion less than 3%.
e) List all sources with proven reserves greater than 100,000m^3 in an area (defined by co-ordinates).

29 Such lists of sources can be printed out with details on pre-programmed report forms. Examples of such report forms are presented as Figures 5 and 6.

30 Kabupaten summary sheets for West Java can be drawn up and an example is presented as Figure 6. Such sheets list the aggregate sources for each kabupaten together with the main elements of information with respect to location, quality and quantity. For further information and more detail on particular sources reference can be made to the aggregate source reports within Kabupaten Material Manuals.

31 These kabupaten summary sheets are in turn summarised in the West Java provincial summary sheet which presents the resources of each kabupaten. These sheets provide the technical information presented in the main report for this part of the TARP.

32 Further development work has also been undertaken at TRRL with respect to the system required to manage the computerised database

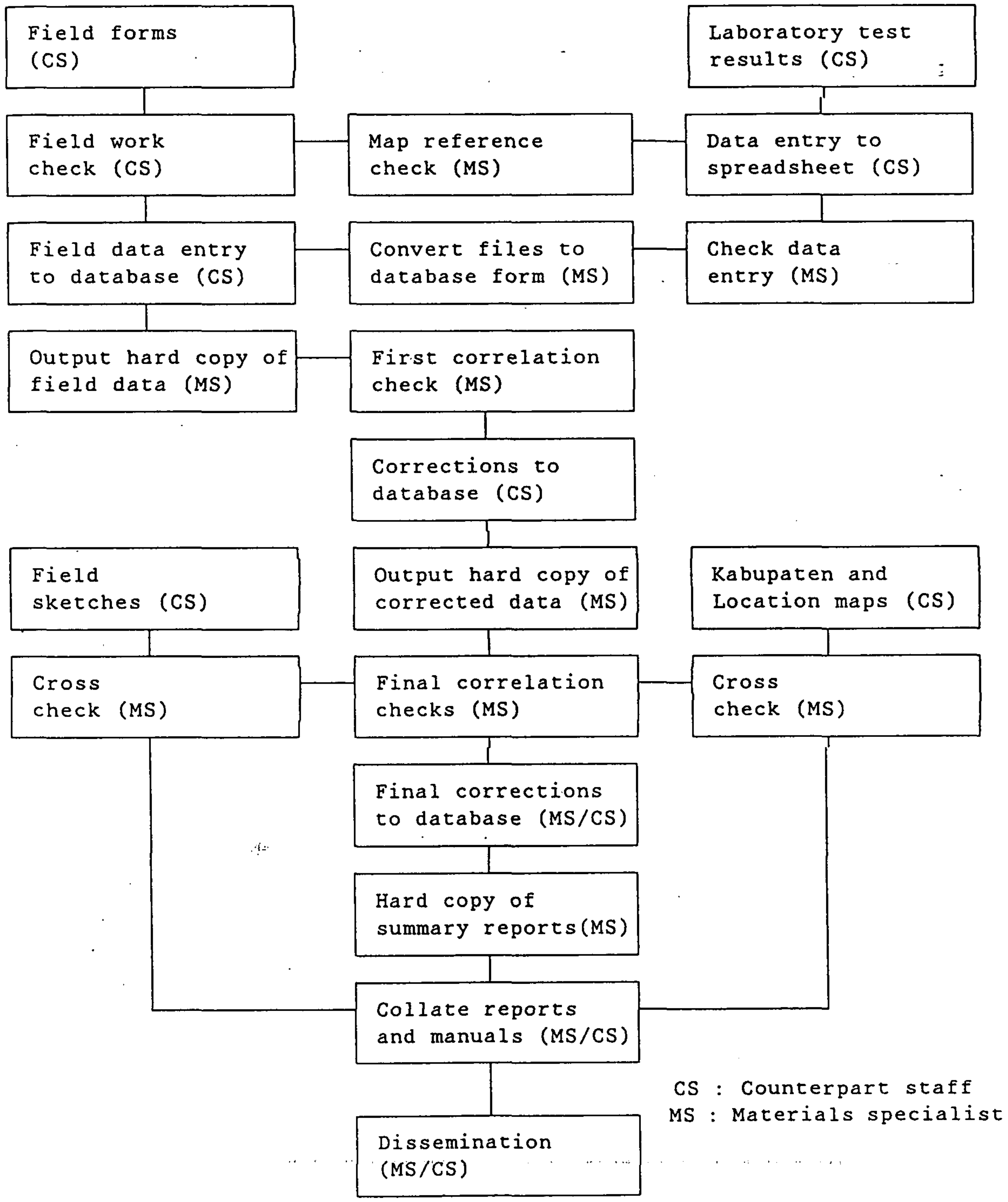

Figure 4 : Cross checking and correlation procedure for RMI database

Figure 5: Example terrain unit summary sheet

ROAD MATERIALS INVENTORY TERRAIN SUMMARY
TERRAIN UNIT 10

Keb.	Loc.	M or P	M/P No.	Product Source	Mat/Prd Type	Sample No.	Sample Size	Smdt No.	WA	SSD	LAA	AIV	ACV	10%F (T)	Flakiness	Elongation	Strip No.	Grading; Passing Sieve 2.5"	1.5"	3/4"	3/8"	#4	#8	#16	#30	#50	#100	#200	F.M	%Wash Fines	Org No.
9	28	M	1		Ba	1	Bould		1.09	2.66	22	7	17		11	28	1	0	0	0	0	0	0	0	0	0	0	0	0.00	0.0	-
8	2	M	1		Aa	1	Bould		1.29	2.74	20	7	19		14	18	1	0	0	0	0	0	0	0	0	0	0	0	0.00	0.0	-
8	10	M	1		Aa	1	Bould	50	0.95	2.77	16	12	17		22	19	1	0	0	0	0	0	0	0	0	0	0	0	0.00	0.0	-
8	20	M	1		Aa	1	Bould	36	2.12	2.70	17	5	17		19	25	1	0	0	0	0	0	0	0	0	0	0	0	0.00	0.0	-
8	25	P	1	Ab	6	1	Bould		1.42	2.78	27	12	26		13	16	1	0	0	0	0	0	0	0	0	0	0	0	0.00	0.0	-
8	21	M	1		Ba	1	Sand		2.52	2.72					0	0	-	100	100	100	100	84	72	54	30	9	1	0	3.50	3.2	1
8	21	M	2		Aa	2	Bould		1.41	2.75	16	9	18		16	25	1	0	0	0	0	0	0	0	0	0	0	0	0.00	0.0	-
8	3	M	1		Ba	1	Cobb		4.66	2.44	43	17			0	0	-	0	0	0	0	0	0	0	0	0	0	0	0.00	0.0	-
8	3	M	1		Ba	1	Grav		5.37	2.50	32	12			0	0	-	81	75	67	56	48	0	0	0	0	0	0	0.00	0.0	-
8	3	M	1		Ba	1	Sand		1.61	2.79					0	0	-	100	100	100	100	100	79	59	34	12	3	1	3.10	1.1	1
8	7	M	2		Bj	1	Bould		1.72	2.73	18	6	19		16	20	1	0	0	0	0	0	0	0	0	0	0	0	0.00	0.0	-
8	7	M	2		Bj	2	Cobb		2.37	2.67	21	8	20		7	17	-	0	0	0	0	0	0	0	0	0	0	0	0.00	0.0	-
8	7	M	2		Bj	2	Sand		2.58	2.76					0	0	-	100	100	100	100	100	90	75	47	18	6	2	2.60	3.9	2
8	7	M	2		Bj	2	Grav		2.71	2.66	24	12			0	0	-	73	55	44	35	22	0	0	0	0	0	0	0.00	0.0	-
8	7	M	2		Bj	3	Sand		2.40	2.72					0	0	-	100	100	100	100	95	85	70	35	13	4	1	0.00	4.1	2
8	18	P	1	Ba	1	1	Sand		2.08	2.76					0	0	-	100	100	100	100	82	72	60	40	13	2	0	3.30	2.9	1
8	18	P	1	Ba	1	1	Grav		5.37	2.48	33	11	25		0	0	-	100	99	77	28	3	0	0	0	0	0	0	0.00	0.0	-
8	26	M	1		Ba	1	Sand		3.01	2.79					0	0	-	100	100	100	100	100	82	61	34	16	6	3	3.00	2.1	1
8	16	M	1		Ac	1	Grav		7.48	2.46	34	11			0	0	-	79	71	65	55	45	0	0	0	0	0	0	0.00	0.0	-
8	16	M	1		Ac	1	Sand		2.96	2.74					0	0	-	100	100	100	100	100	80	57	32	11	5	2	3.20	1.9	1
8	19	M	2		Aa	1	Bould	11	1.52	2.75	19	7	18		15	20	1	0	0	0	0	0	0	0	0	0	0	0	0.00	0.0	-
8	27	M	2		Aa	1	Bould	12	1.79	2.69	38	13	28		11	17	1	0	0	0	0	0	0	0	0	0	0	0	0.00	0.0	-
8	17	M	1		Bj	1	Sand		2.63	2.72					0	0	-	100	100	100	100	97	89	70	38	11	3	1	2.90	0.2	1

Figure 6: Example of district summary sheet

ROAD MATERIALS INVENTORY KABUPATEN SUMMARY SHEET Province 22 - JAWA BARAT District 3 - BOGOR 24/10/89

1. Location Number	2. Name	3. Road from	4. Road to	5. Link	6. Class	7. CHG KM	8. Access KM	9. Access State	10. Materials	11. %	12. Reserves(*) Proven	13. Potential	14. Quality Act C F	Pot C F	15. Extraction Methods	16. Processing Plant	17. Development Restraints
01	BOJONG KULUR	WANAHERANG	BOJONG KULUR	41.1	2	14.0	1.2	2	(1)Ba (2)Be	35 ALLUVIUM 65 TERRACE DEPOSITS	<1	5-10,	0 3 2 3	0 2 1 2	4	4	5
02	SENAPATI	CIJEUNGIR	CISANGKAL	65	3	5.0	1.1	2	(1)Ba (2)Be	20 ALLUVIUM 80 TERRACE DEPOSITS	10-25	50-100	1 2 1 2	1 1 1 1	3	5 6	3 5
03	RENGAS JAJAR	CIBUNGUR	LEBAK WANGI	73	3	5.0	4.0	1	(1)Ab	100 IGNEOUS INTRUSIVE	50-100	>250	2 2	2 1	1	1 2	5
04	BOJONG RANGKAS	CIKAMPAK	CIBENING	13	3	1.5	0.6	2	(1)Ba (2)Be	35 ALLUVIUM 65 TERRACE DEPOSITS	<1	<1	2 2 2 2	1 2 1 2	4	4	5
05	LEBAK PASAR	CIKAMPAK	SEMPLAK	15	3	2.5	0.2	2	(1)Ba	100 ALLUVIUM	<1	<1	2 3	1 2	4	4	3 4
06	G. PANEMA	CIJENGIR	CIHEULANG	69	3	2.2	0.7	2	(1)Aa	100 IGNEOUS EXTRUSIVE (L	2.5-5	10-25	2 0	1 1	4	4	4 5
07	CIOMAS RAHAYU	CIOMAS	KERETEG	47	3	1.8	0.8	2	(1)Be (2)Ba	85 TERRACE DEPOSITS 15 ALLUVIUM	1-2.5	25-50	3 2 3 2	2 2 2 2	2	5	5
08	G.DAGO	CIHEULANG	PARUNG PANJANG	70	3	5.2	0.3	2	(1)Aa	100 IGNEOUS EXTRUSIVE (L	>250	>250	1 2	1 1	1 2 3	1 2 5 6	5
09	BUGEL	GN.SINDUR	BOJONG PINANG	67.1	3	3.5	2.2	2	(1)Ba (2)Be	40 ALLUVIUM 60 TERRACE DEPOSITS	2.5-5	5-10,	2 3 1 2	1 1 1 1	2 3	3 5 6	5
010	JAMPANG	GN.SINDUR	BOJONG PINANG	67.1	3	6.5	0.9	2	(1)Ba (2)Be	40 ALLUVIUM 60 TERRACE DEPOSITS	2.5-5	5-10,	1 2 1 3	1 1 1 1	2 3	2 3 5 6	3
011	BABAKAN	CIBINONG	WANAHERANG	43	3	16.8	0.4	2	(1)Ba	100 ALLUVIUM	<1	1-2.5	3 3	3 2	4	0	5
012	MEDANG	CICANGKAL	CIKOLEANG	67	3	3.0	1.5	2	(1)Be	100 TERRACE DEPOSITS	25-50	100-250	3 2	2 2	3	5 6	3 5
013	PAGELARAN	CIOMAS	KALAPA TUJUH	47	3	2.2	0.8	2	(1)Be	100 TERRACE DEPOSITS	10-25	50-100	2 2	1 1	2	6	5
014	PAGUTAN/RUMPIN	GERENDONG	JEUNGIR	64	3	3.4	1.5	2	(1)Aa (2)Ba	70 IGNEOUS EXTRUSIVE (L 30 ALLUVIUM	<1	2.5-5	2 0 3 3	1 1 1 2	1 4	4	5

Report Libraray: RMI_IRE.RPI Report.Name: District Summary effectively. Additional training has been given to IRE staff by TRRL on aspects of this system including a course at IRE.

DATA ANALYSIS AND TERRAIN EVALUATION

33 Analysis of the data recovered from the TARP RMI is continuing at TRRL, with particular attention being given to the potential correlation of aggregate type and quality with terrain.

34 Preliminary work has concentrated on aggregate properties in relation to material types. Table 2 indicates the range of materials encountered and their potential quality as sources of aggregate. Figures 7 and 8 present the numbers and sizes of the two largest groups of locations; those containing igneous bedrock and those containing alluvial, or terrace and related materials. The preponderance of andesitic/basaltic materials in both these groups is reflected in the their high potential for good quality coarse aggregate. Only the laharic (Ac) materials have a poor potential in this regard.

35 The ability to achieve this potential quality will largely rely on methods of production. The majority of aggregate sources in West Java still rely on labour intensive hand extraction and hand crushing methods in relatively small locations. From the database it can be seen that in total only 10% of the quarries are equipped with crushers. A more detailed study shows that there is a difference related to source type; 17% of the hard rock quarries have crushers whereas they occur in only 5% of the alluvial/terrace quarries.

36 Alluvial and terrace related materials are currently the main source of fine aggregate in West Java. The majority of these sources have no adequate screening facilities and this, in conjunction with the rounded to sub-rounded nature of most of the alluvial sand, produces less than top quality fine aggregate which may, nevertheless, be adequate for most road construction needs.

37 The coarser alluvial and terrace sources have the potential to produce both fine and coarse aggregate provided production methods are capable of removing poorer quality material that is frequently contained in, and masked by, the good material. This poor material may frequently be contained with the smaller sizes of material, as indicated by an analysis of water absorption against original sample size (Figure 9) .

38 The current RMI deals only with current aggregate locations and a major aspect of future work would require adapting the pilot study procedures to include a methodology for materials exploration. Terrain evaluation is a potentially powerful aid in extrapolating available materials information and has been successfully used in materials exploration for many years (Beaven and Lawrance, 1982). In the case of the current project, terrain evaluation procedures are being researched with respect to potential extensions of the RMI.

Table 2 : Maximum potential material quality; Road Materials Survey, West Java

Material types Code	Description	Number of materials	Quality of materials Coarse aggregate Good	Fair	Poor	Fill	Fine aggregate Good	Fair	Poor	Fill
Aa	Igneous extrusive	122	94	16	9	3	81	7	1	6
Ab	Igneous intrusive	57	48	7	1	0	46	3	0	2
Ac	Pyroclastic	84	14	29	32	5	12	59	7	1
Ad	Sedimentary (clastic)	14	3	5	1	1	0	10	0	0
Ae	Limestone	20	9	7	3	0	9	0	0	1
Af	Metamorphic	1	1	0	0	0	0	0	0	0
Ba	Alluvial	353	211	46	13	4	100	234	5	0
Bb	Lacustrine	6	0	1	1	0	6	0	0	0
Bc	Colluvial	0	0	0	0	0	0	0	0	0
Bd	Beach deposits	10	0	0	0	0	0	10	0	0
Be	Terrace/ old fan	127	81	25	8	0	53	74	0	0
Bf	Scree	1	1	0	0	0	1	0	0	0
Bg	Weathered rock	1	1	0	0	0	1	0	0	0
Bh	Residual soil	0	0	0	0	0	0	0	0	0
Bj	Volcanic debris/ sand	22	1	2	8	5	1	19	0	2
Bk	Lateritic materials	0	0	0	0	0	0	0	0	0

Table 3 : Numbers of materials and maximum potential quality of aggregate in grouped terrain units

Terrain unit group	Number of materials											Quality of materials							
												Coarse				Fine			
	Aa	Ab	Ac	Ad	Ae	Af	Bf	Bj	Ba	Bb	Be	C1	C2	C3	C4	F1	F2	F3	F4
Low plains	1	0	1	0	0	0	0	1	65	0	11	32	10	6	5	21	57	1	0
Low-moderate hills	4	3	0	0	2	0	0	0	2	0	2	5	5	2	0	5	2	0	0
Intermontane plains/basins	6	2	9	0	0	0	0	2	38	0	8	43	13	6	0	29	31	4	0
Volcanic slopes	10	1	28	0	0	0	1	4	18	0	11	33	15	18	1	26	36	0	1
Steep hills/ ridges/mountains	16	3	10	0	0	0	0	3	13	0	2	25	5	12	4	9	18	3	2

Figure 7 : Proven and potential material reserves - igneous bedrock

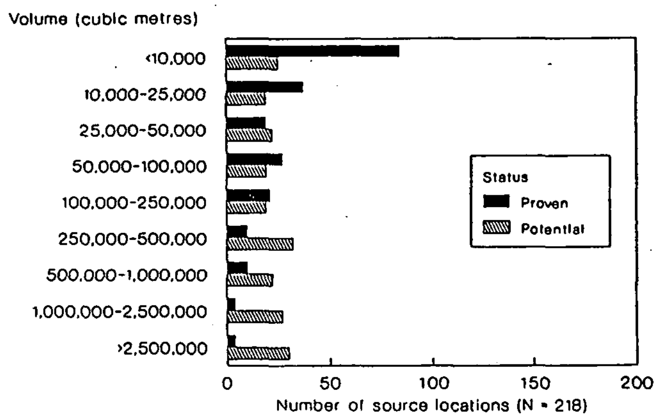

Figure 8 : Proven and potential material reserves - alluvial/terrace deposits

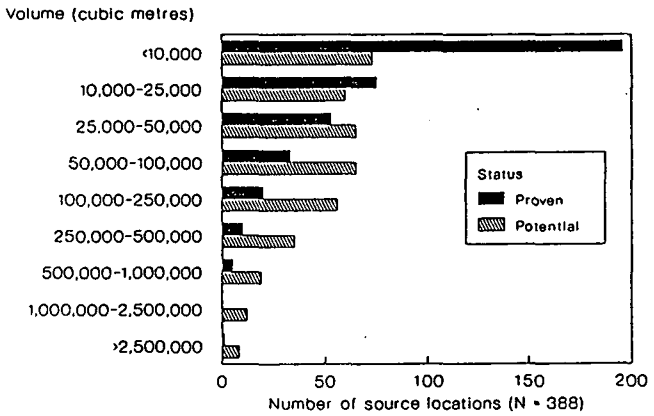

Figure 9 : Comparison of water absorptions for differing original clast sizes; alluvial/terrace deposits.

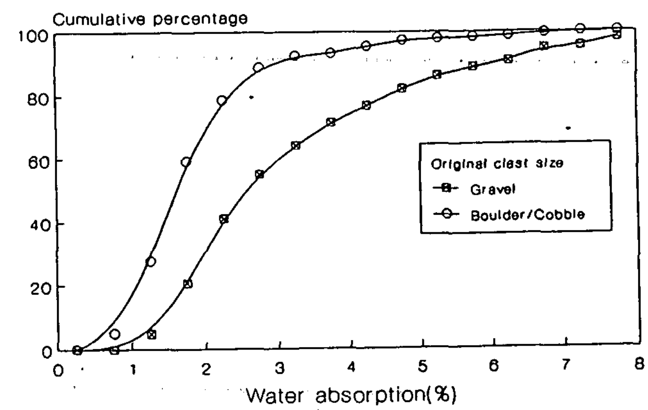

Table 4 : Numbers of materials and maximum potential quality of aggregates of volcanic slope terrain units

Terrain unit	Number of materials											Quality of material							
												Coarse aggregate				Fine aggregate			
	Aa	Ab	Ac	Ad	Ae	Af	Bf	Bj	Ba	Bb	Bc	Good	Fair	Poor	Fill	Good	Fair	Poor	Fill
Dissected radial slopes (undifferentiated)	1	0	23	0	0	0	0	0	9	0	6	15	10	14	0	15	24	0	0
Dissected younger volcanic slopes	2	0	0	0	0	0	0	0	1	0	0	2	0	1	0	1	1	0	0
Dissected older volcanic slopes	1	0	4	0	0	0	1	2	5	0	5	7	4	1	0	5	6	0	0
Dissected slopes (undifferentiated)	5	0	0	0	0	0	0	0	0	0	0	4	1	0	0	2	1	0	1
Undulating slopes (undifferentiated)	0	1	1	0	0	0	0	2	0	0	0	1	0	2	1	1	3	0	0
Undulating slopes over volcanics and sediments	1	0	0	0	0	0	0	0	3	0	0	4	0	0	0	2	1	0	0

39 At the time of the current research a terrain evaluation of Java had not been completed. It was decided therefore to take a representative section of West Java and produce a preliminary terrain unit map based on available geological and topographic maps in conjunction with the relevant Landsat images. R&R Relational Report Writer was used to search for all aggregate locations within the trial area; these were subsequently plotted on the map and the relevant terrain units entered into the database. R&R Relational Report Writer was then further utilised to collate aggregate information with respect to terrain units. Relevant material and aggregate quality data collated with respect to terrain units are presented in Tables 3 and 4.

40 Although this terrain and aggregate research is ongoing at TRRL some preliminary observations may be made on the occurrence of aggregate sources with respect to terrain.

a) The quality of potential bedrock aggregate sources is directly influenced by geology; which also influences surface morphology. In addition, the condition of the bedrock will have been influenced by weathering and hence by terrain.

b) The position of bedrock quarries within potential sources is influenced by accessibility, which is likely to be a function of the detailed terrain unit morphology (land facets).

c) The characteristics of alluvial or terrace aggregate sources are a function of the bedrock materials from which they were derived and hence may be a function of adjacent terrain units in addition to their own (Table 5).

Table 5

Median field gradings for alluvial/terrace gravels in a range of differing terrains.

Unit		Estimated Field Grading (%)			
No.	Bldr	Cobble	Gravel	Sand	Fines
7	35	30	20	10	5
9	20	35	30	10	5
27	5	10	20	60	5
3	0	0	5	90	5

d) The exact location of alluvial reserves is a function of detailed river morphology. In the case of the main Cimanuk river system in the trial area the availability of access routes is a governing factor.

41 Terrain evaluation may be used to indicate areas likely to contain potential material reserves. Extrapolation of data from known sources in conjunction with terrain evaluation may give additional information as to potential quality and uses.

42 For their effective use in materials surveys a terrain evaluation should take into account geology as well as morphology. Work with the West Java trial area and the existing Bakosurtinal maps for Sumatera has indicated that the latter would be better suited to materials survey if the geological emphasis was greater. In contrast the preliminary work on West Java would be improved with a greater morphological input, particularly with respect to alluvial and old river terrace forms.

43 Work undertaken within the West Java trial area has shown the value of air photography in identifying potentially useful lava and laharic flows in this terrain. Work has also indicated the extent of potential alluvial and terrace sources.

USERS OF RMI

44 Users of the West Java inventories fall into three broad groups.

Planners. Planners can use information on the location of major material sources as a factor in route alignment decisions and general infrastructure development. Information on cost and location can be used to work up realistic figures for material and haulage costs.

Engineers. Engineers can use road materials inventory information in a number of different ways. Design engineers may be able look at the types of material available and adopt road designs compatible with them, to produce more cost-effective end products. District road engineers, consultants and contractors may use the database to find and assess local materials for their immediate requirements.

Researchers. Researchers may use the database information to undertake studies into a whole range of practical road material oriented topics. For instance, the relationships between material performance, terrain and geology can be studied to provide a rational methodology for developing new sources. The accumulated laboratory information could lead to further research into testing procedures relevant to the governing materials and climate.

FURTHER DEVELOPMENT AND MAINTENANCE

45 The TARP inventory project has laid the foundation for further road and construction materials work being undertaken at IRE. Opportunities derive from the use of the database information, from the

adaptation of the systematic methodology and from the results of the experience gained by the IRE staff.

46 The possible areas of further work fall into four related fields:-

a) Implementation of comprehensive database management and information dissemination system for the RMI at IRE.
b) The extension of the current RMI to form a national inventory.
c) The adaption of the methodology to consider detailed resource surveys and assessments.
d) Aggregate research

47 The TARP pilot study has confirmed the feasibility, and potential usefulness, of undertaking a road materials inventory on a provincial basis. It is a logical step to consider extending this to the other provinces of Indonesia and, in the process, to take into account potential as well as actual sources of aggregate. It is considered that the establishment of a framework for a national inventory and database would be an effective first stage in this extension.

48 One possible way of developing this framework has been discovered, using the land system maps which have been recently completed for the whole of Indonesia. These maps were prepared by the Departemen Transmigrasi to give a consistent basis for the regional planning processes (Wall et al., 1988). They were used in the preliminary survey of South Sumatera.

49 A provincial data bank of existing aggregate sources may be used as a starting point for more detailed resource assessments. These may be applied at individual road project level or comprise more general surveys of particular material types or geographical entities. These studies, involving both actual and potential sources, may seek to make more detailed recommendations as to material production and use.

50 The existing database provides a basis for executing further research on the more detailed identification of aggregate properties in Indonesia. This work could involve examining current material standards used in Indonesia and assessing regional trends in the availability of materials, production technology and costs.

51 An inventory such as the current RMI is a resource that requires continuous support. Unless given this support in terms of updating of information and user feedback its usefulness will gradually diminish.

52 Information relating to the various data fields will change on differing time scales; and some are unlikely to change at all. Changes in some data fields will have important knock-on effects on others, and thus can be considered key factors to be monitored. Examples of such key factors are as follows:-

a) Operational or development status
b) Extraction method
c) Production method

The updating of the RMI may be achieved in a number of ways, broadly outlined below.

Total provincial resurvey. This is likely to be expensive and time consuming, but could be part of, for example, a complete provincial resource survey. Such a total resurvey might be considered on a 10-15 year cycle.

Partial resurvey or project update. This may form part of more detailed route corridor assessments or as a consequence of road projects being undertaken. The involvement and feedback from aggregate users is essential in this process.

Ad hoc location update. This would be based on kabupaten and local use of aggregate sources and requires good communication between kabupatens and the managers of the database. At this level it is suggested that whenever sources are visited, perhaps by DPU or Bina Marga engineers, obvious changes are noted and forwarded to the database managers or held until information is collected on a regular basis.

Table 6

Maintenance programme

Source	Reserves m^3	Rate m/week	Source Life (Months)	Survey Date	Work-out Date
1	200 000	500	100	23.06.88	23.10.96
2	50 000	1 000	10	01.09.88	01.07.89

Maintenance update. This could be an updating programme based on the perceived working life of the sources and run using the database system. This is illustrated in table 6.

53 A maintenance programme could be devised to highlight automatically sources that have reached key stages in their proven working life - say a 25 or 50% depletion. The key input to this would be a knowledge at local level of any major changes in output rate. Because the current TARP inventories are held on a computerised database, changes may be easily made through the dBASE III PLUS editing procedures.

54 Associated research on the rate of change of database information will lead to the more effective upkeep of future inventories;

for example, the recharge capabilities of alluvial sources of sand, gravel and boulder during flood seasons.

SUMMARY

55 A Road Materials Inventory methodology has been designed and tested in West Java and has indicated its potential usefulness as a tool for engineers, planners and researchers. Although its effectiveness will depend on feedback from users and continued regular updating, the methodology is considered suitable to expand the inventory to a national scale.

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