EXPERIMENTAL STUDY OF STEEL FIBRE REINFORCED CONCRETE SIMPLY SUPPORTED BEAM

by
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JOINT UNPAR - ASCE SEMINAR
ON
THE STATE OF THE ART OF
CIVIL ENGINEERING PRACTICE
IN INDONESIA

Bandung, 18 May 1991
Parahyangan Catholic University

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Abstract :Concrete is by nature not suitable to resist tension. So reinforcing was placed to bear the tensile stress. Sometimes we need a lot of reinforcing, especially at joints of an earthquake resisting frame. To reduce that amount in order not to have difficulties in casting the concrete, an experimental study has been provided by adding steel fibres in the mortar. It showes a certain increase of the tensile strength of the concrete.

Introduction

It has been known that the tensile strength of concrete is very low. By placing mild steel for the reinforcing, the tensile strength can be improved. In some cases, e.g. at beam-column joints of earthquake resisting frames, a great amount of reinforcing is required. And this will create difficulties to produce a non-porousive concrete.

To overcome that problem, a certain percentage of steel fibres will be added in the mortar, sothat it will reduce the mild steel as the reinforcement.

Description of the Tests

Dramix ZC 60/80 steel fibres of Hooke-ends type was used in the tests. ZC 60/80 means 60 mm long, 80/100 mm diameter, hooked at the ends, and they are bundled by glue. The fibre concrete shear stress is 24 kg/cm^2. Concrete of grade K-225 is mixed by 0 %, 0.5 % and 1 % Dramix steel fibres. The crushing strength was obtain by testing cube samples of 15x15x15 cm. And split cylender tests was performed by testing cylenders of 15 cm diameter x 30 cm long.

Fig.1. Steel Fibre of Hooke-ends type.

All of the samples are wet cured.

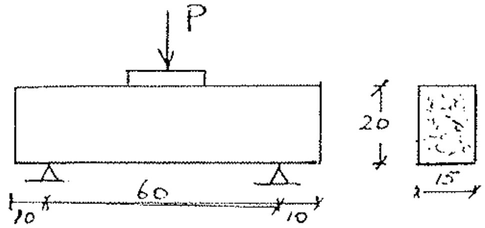

Fig.2. Flexural test model.

To provide the flexural tests, a simply supported beam was modelled according the ASTM standard (see fig.2.). The results of the tests are summarized in tables.

Table 1 - 3: crushing tests of 0 %, 0.5 %, 1 % fibres at 28 days.

Table 4 - 6: split cylender tests of the same fibres percentage and age.

Table 7 - 9: ultimate flexural tests of the beam model.

Discussion

Results of the experimental study are quite different from the theoretical analysis (see tables 10 - 11).

The tensile stress was determeined by the split cylender tests. The formulas used theoretically are :

$$\sigma_{ku} = \frac{2\ P}{\pi\ d\ l}\ .C$$

$$C = 1 - \frac{D}{2\ a}\ (\ \alpha - \sin \alpha\ ) \quad \text{and} \quad \alpha = 2\ \text{arc tan}\ \frac{a}{2\ r}$$

For 3-dimensional steel fibre RC :

$$\sigma_{ku} = \frac{1}{2}\ V_s\ \tau\ L/D \quad \text{where } L/D = 75$$

$$\tau = 24\ kg/cm^2$$

While from the tests we get a quite high tensile stress. Both of the results are showed in table 10.

The ultimate flexural stress was determined by three methods i.e. : theoretically, according ASTM standard, and by the stress block principles.

The formula for this theoretically calculation is :

$$\sigma_l = V_s \tau L/D \; 39/32$$

While according the ASTM standard :

$$\sigma_l = \frac{P\ l}{b\ d^2}$$

Determination of the flexural stress by considering the stress block, will assume the location of the neutral axis as 1/4 d from the most outer compressive fibre of the model. Thus :

$$M = T * 10.83$$

$$\sigma_l = \frac{T}{\text{section area below neutral axis}}$$

The results of all the calculation above are then verified by the Finite Element Method. The comparison of the results are tabularized in table 11.

Conclusion

1. How to spread the fibres homogenously in the mortar is quite a problem.
2. Increasing the fibres percentage and L/D ratio will give better quality of concrete, but the workability will be a problem. The aggregate size will influence the percentage of the fibres of a reasonable workability. A maximum of 10 mm diameter of aggregate will give an optimum percentage of fibres.
3. The steel fibres improved the ductility of concrete. It means steel fibre RC is not as britlle as plain concrete.

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Sample No.	Age days	Weight gr	P cm	L cm	T cm	Area cm^2	Volume cm^3	Load Kg	σ crushing Kg/cm^2	Weight Vol gr/cm^3
1	28	7800	15,10	15,10	15,05	228,01	3431,55	54044,63	237,03	2,27
2	28	7860	15,15	15,00	15,10	227,25	3431,48	54554,49	240,06	2,29
3	28	7820	15,20	15,10	15,15	229,52	3477,23	54044,63	235,47	2,25
4	28	7850	15,10	15,00	15,00	226,50	3397,50	55064,34	243,11	2,31
5	28	7810	15,10	14,90	15,15	224,99	3408,60	55064,34	244,74	2,29
6	28	7900	15,05	15,00	15,25	225,75	3442,69	54044,63	239,40	2,29
7	28	7850	15,20	15,00	15,15	228,00	3454,20	53534,78	234,80	2,27
8	28	7800	15,15	14,95	15,21	226,49	3444,95	54044,63	238,62	2,26
9	28	7875	15,00	15,00	15,09	225,00	3395,25	53024,92	235,67	2,32
10	28	7760	15,10	15,00	15,14	226,50	3429,21	53024,92	234,11	2,26

$\bar{\sigma}'_{bm}=238,30$

Table 1. Crushing tests results of 0 % fibre at 28 days.

Sample No.	Age days	Weight gr	P cm	L cm	T cm	Area cm^2	Volume cm^3	Load Kg	$\sigma_{crushing}$ Kg/cm^2	Weight Vol gr/cm^3
1	28	8025	15,05	15,05	15,10	226,50	3420.15	61182,60	270,12	2,35
2	28	8050	15,18	15,04	15,20	228,31	3470,31	63731,88	279,15	2,32
3	28	8040	15,24	15,13	15,21	230,58	3507,14	63222,02	274,19	2,29
4	28	7950	15,05	14,97	15,13	225,30	3408,77	62202,31	276,09	2,33
5	28	7980	15,04	15,02	15,20	225,90	3433,69	68830,43	304,69	2,32
6	28	8050	15,40	15,14	15,05	233,16	3508,99	61182,60	262,41	2,29
7	28	7820	15,00	15,00	15,15	225	3408,75	62202,31	276,45	2,29
8	28	7930	15,13	15,04	15,00	227,56	3413,33	64241,73	282,31	2,32
9	28	8000	15,15	15,05	15,05	228,08	3431,51	60162,89	263,86	2,33
10	28	8000	15,13	14,90	15,20	225,44	3426,64	63222,02	280,44	2,33

$\bar{\sigma}'_{bm}=276,97$

Table 2. Crushing tests results of 0.5 % fibre at 28 days.

Sample No.	Age days	Weight gr	P cm	L cm	T cm	Area cm^2	Volume cm^3	Load Kg	σ crushing Kg/cm^2	Weight Vol. gr/cm^3
1	28	8100	15,14	15,06	15,10	228,01	3442,93	70869,85	310,82	2,35
2	28	8120	15,15	15,05	15,10	228,01	3442,91	81576,80	357,78	2,36
3	28	8000	15,00	15,00	15,05	225,00	3386,25	72399,41	321,78	2,36
4	28	7950	15,10	14,85	15,00	224,24	3363,53	65261,44	291,04	2,36
5	28	8050	15,20	15,15	14,95	230,28	3442,69	74948,69	325,47	2,34
6	28	8075	15,20	15,10	15,00	229,52	3442,80	67300,86	293,22	2,35
7	28	8010	15,10	15,10	15,05	228,01	3431,55	66281,15	290,69	2,33
8	28	8050	15,15	14,95	15,00	226,49	3397,39	73928,98	326,41	2,37
9	28	8000	15,00	14,95	15,15	224,25	3397,39	71379,70	318,30	2,35
10	28	8010	15,15	15,10	14,95	228,77	3420,03	73419,12	320,93	2,34

$\bar{\sigma}'_{bm}=315,64$

Table 3. Crushing tests results of 1 % fibre at 28 days.

Cylender NO	D Ø (cm)	T L (cm)	Load Kg	$\sigma_{tensile, max}$ Kg/cm^2
1	15,20	29,90	11216,81	15,611
2	14,90	29,80	11216,81	15,975
3	15,10	30,00	9177,39	12,814
4	15,20	30,20	10197,10	14,057
5	15,00	29,90	9177,39	12,941
6	15,00	30,30	9687,25	13,480
7	15,10	30,00	10197,10	14,237
8	15,00	30,40	11216,81	15,557
9	15,20	29,80	9687,25	13,528
10	15,10	30,20	10197,10	14,143

$\bar{\sigma}_{ku} = 14,234$

Table 4. Split cylender teats results of 0 % fibre at 28 days.

Cylender NO	D Ø (cm)	T L (cm)	Load Kg	$\sigma_{tensile,max}$ Kg/cm^2
1	15,00	30,00	13256,23	18,630
2	15,00	29,90	12746,38	17,974
3	15,10	29,90	13256,23	18,570
4	14,90	30,00	12746,38	18,032
5	15,00	30,30	12236,52	17,027
6	14,90	30,20	13256,23	18,629
7	15,20	30,10	12236,52	16,917
8	15,10	29,80	13256,23	18,633
9	15,00	29,90	14275,94	20,130
10	15,10	30,00	13256,23	18,508

$\bar{\sigma}_{ku} = 18,305$

Table 5. Split cylender tests results of 0.5 % fibre at 28 days.

Cylender NO	D Ø (cm)	T L (cm)	Load Kg	$\sigma_{tensile,max}$ Kg/cm^2
1	15,10	29,80	15805,51	22,216
2	15,10	30,00	14785,80	20,644
3	15,00	29,90	15295,65	21,568
4	15,10	30,20	14275,94	19,800
5	15,10	29,80	15295,65	21,499
6	15,10	30,40	15295,65	21,075
7	15,20	30,20	15805,51	21,779
8	15,10	30,00	15805,51	22,068
9	14,90	29,90	15295,65	21,711
10	15,00	30,20	15295,65	21,354

$\bar{\sigma}_{ku} = 21,371$

Table 6. Split cylender tests results of 1.0 % fibre at 28 days.

Beam NO	L cm	b cm	d cm	Load P kg	σ flex, ult. kg/cm^2
1	60	15	20	2800	28
2	60	15	20	2900	29
3	60	15	20	2700	27

$\sigma_1 = 28$

Table 7. Flexural tests results of beam models with 0 % fibre at 28 days.

Beam NO	L cm	b cm	d cm	Load P kg	σ flex, ult. kg/cm^2
1	60	15	20	3600	36
2	60	15	20	3450	34,50
3	60	15	20	3250	32,50

$\sigma_1 = 34,33$

Table 8. Flexural tests results of beam models with 0.5 % fibre at 28 days.

Beam NO	L cm	b cm	d cm	Load P kg	$\sigma_{flex, ult.}$ kg/cm^2
1	60	15	20	4800	48
2	60	15	20	4950	49,50
3	60	15	20	5000	50

σ_1 = 49,17

Table 9. Flexural tests results of beam models with 1.0 % fibre at 28 days.

Steel fibre percentage	0 %	0,5 %	1 %
σ_{ku} (theoretical) (kg/cm^2)	-	4,5	9,0
σ_{ku} (experimental) (kg/cm^2)	14,234	18,305	21,371

Table 10. Theoretical and Experimental Tensile Strength.

Steel fibre percentage	0 %	0,5 %	1,0 %	1,5 %
σ_1 (theoretical) (kg/cm^2)	-	10,98	21,94	32,91
σ_1 (ASTM experimental) (kg/cm^2)	28	34,33	49,17	54,33
σ_1 (stress block experimental) (kg/cm^2)	11,59	14,19	20,28	22,40
σ_1 (FEM experimental) (kg/cm^2)	12,60	15,20	21,60	23,60

Table 11. Theoretical and Experimental Flexural Strength.

FRACTURE MECHANISM OF CONCRETE UNDER COMPRESSIVE LOAD

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FRACTURE MECHANISMS OF CONCRETE UNDER COMPRESSIVE LOADS *)

Dicky Rezady Munaf, Ph.D **)

ABSTRACT

The nature of progressive crack growth in plain concrete under compressive loads was investigated. A conceptual model was formulated to describe crack extension at a given stress as well as the manner in which ultimate failure of concrete takes place. Compression tests were performed on concrete prisms to investigate the nature of crack growth at the macroscopic level. In addition, analytical and experimental model studies were conducted using fracture mechanics concepts in which the behavior of isolated cracks under compressive loads was studied.

I. Introduction

Considerable research work has been devoted to the determination of the behavior of plain concrete under various modes of loading. Such studies have concentrated on the strength-deformation characteristics of the material. By comparison, much less work has been done to determine the effect of the structure of concrete on its macroscopic behavior. Such studies have been concerned with the investigation of material behavior and/or with modeling of such behavior.

Investigators of the material behavior have been concerned with the determination of indicators of the material deterioration under load. It is generally acknowledged that concrete cracks even before load is applied (1,2). Such cracking can be attributed to a number of factors such as volume changes during setting and hardening and temperature changes during hydration. Under short-time loads, cracking increases significantly at stresses in the order of 25-55 % of the short-time compressive strength f_{cu} (1,3). One investigator has pointed out that initial cracking under load is roughly oriented at angles close to 25° from the loading direction (4). These cracks are mostly concentrated at the interface of large aggregates (1,3). Bridging of isolated bond cracks through mortar to form continous crack patterns starts to occur at stresses in the order of 7o-9o % of f_{cu} (1,5). Once microcracks exceed a certain minimum length they are oriented predominantly in a direction close to the direction of loading (2,3,5); although in some tests it has been observed that inclined cracks develop suddenly, leading to immediate failure (6,3).

*) Presented at the "Joint UNPAR-ASCE Seminar" , Bandung, 18 May 1991

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For sustained loading it has been found (3,7) that for stress levels in the order of 7o-9o % of f_{cu}, cracking never stabilizes, and eventually causes failure. Similarly for cyclic loading at high stresses, cracks propagate until failure occurs (3).

Models to simulate the observed behavior can be classified into three general categories: lattice models (8,9,1o), interfacial behavior models (11,12,13,14), and fracture mechanics models (16,15).

In the lattice models concrete is simulated by a lattice structural system. Although some sophisticated lattice models have had success in modeling the stress-strain behavior of concrete (9) their physical resemblance with concrete is very approximate. They do not furnish information on crack growth.

Interfacial behavior models recognize the inherent weakness of the aggregate-mortar interface and try to explain, on the basis of such weakness, how progressive deterioration comes about. In general terms they propose that the interfacial bond is broken at a given stress level for each particular interface orientation, depending on the existing local stresses. After the interface bond is broken, the formation of tensile cracks follows shortly. In some models the formation of tensile cracks is equated to failure, while in others it is just one step in breaking down the system into a number of weaker, slender compression elements which eventually fail. Whereas, these models are helpful in understanding the progressive formation of cracks at aggregate matrix interfaces, they fail to recognize that subsequent crack growth is governed by the stress fields at the crack tips and that, therefore, special attention must be given to individual crack growth.

Fracture mechanics models, on the other hand, emphasize the effect of stress concentrations at crack tips. Glucklich`s work (15) has laid down the foundations for the application of fracture mechanics to concrete. Zaitsev (16) has proposed a failure model which considers voids as the significant factor in the mechanics of crack growth and failure of concrete and cement paste under compressive loads.

Although not directly related to concrete, some noteworthy work on progressive crack growth in compression fields was contributed by Bombolakis (18) in the field of rock mechanics.

McClintock and Walsh (17) analysed the effect of inclined cracks in rock, under the assumption that load transmission across cracks occurs.

Based upon this background information an attempt was made to describe more closely the nature of crack propagation in concrete, and specifically to investigate the mechanisms by which microcracking leads to actual failure.

II. Experimental Study of the Process of Crack Growth

Five series of plain concrete prisms, 1o by 1o cm cross section, and 3o cm high, were tested under short-time, cyclic and sustained compressive load histories in order to study the nature of progressive crack growth and failure. Specimens as-cast were tested as well as specimens from which surface layers 5 mm thick were removed on two sides by sawing. The purpose of sawing the surfaces was to expose the coarse aggregates.

US Type I Portland Cement was used for all test series. For most mixes the mix proportions were 1:3.9:4.5 with a water-cement ratio of o.78. The average 28-day strength of the concrete as determined on 15 by 3o cm dylinders was 23o kgf/cm^2. Further details of the test program can be found in (19).

Longitudinal and lateral strains were measured on two opposite vertical sides of the specimens. The other sides of the prisms were used to investigate crack growth by observing surface cracks using a fluorescent ink penetrant and photographic equipment. This technique is known as the filtered particle method. The fluorescent ink consists of a dispersion of fine fluorescent particles in a fluid. The molecules of the fluid, being smaller than a particular crack, are attracted to the interior of a crack, as a result of the increased absorption area offered by a crack. Since the fluorescent particles are, in general, larger than the crack width they are filtered out at the crack surface, forming a line delination of the crack which is readily seen under ultraviolet light. Two cameras equipped with orange filters were used to take pictures of the surfaces at various stages of loading. The photographs covered the center third of the vertical surfaces. To take a picture at a predetermined stress level, the strain was held constant while the ink was applied and allowed to set for 3o seconds. The photographs were then taken and the loading resumed. Fig. 1 shows such photographs of a sawed surface at various stages of loading.

Crack patterns were obtained by tracing the cracks directly from the picture negatives onto transparent plastic. A magnifying lens (8 x) was used to help in identifying the cracks. From the tracings quantitative evaluations of the extent of cracking at various stages of loading were made.

For specimens with sawed surfaces, load independent cracking was mostly concentrated at aggregate interfaces. For specimens with surfaces as-cast, it was concentrated around voids and had random orientation. Increasing the load to o.85 f_{cup} (f_{cup} = short-time compressive strength of prism) caused only a small increase in the extent of cracking. of which most was interfacial. Further increase of the stress level caused a significant increase in the extent of cracking. At o.95 f_{cup}, cracking was no longer restricted to interfaces; previous interfacial cracks were observed to extend into the mortar. At these late stages of loading, the growing cracks had a marked tendency to orient themselves in a direction closer to the direction of loading, a tendency not observed at earlier stages. The rate of overall crack increase was largest when the specimens were strained into the descending portion of the stress-strain curve. For stresses below o.9o f_{cup}, in the descending portion of the curve, wide cracks were found. These cracks varied in orientation from one test to another, but their average orientation usually did not deviate from the direction of applied load by more than 3o^{o}.

For cyclic tests on sawed specimens with a maximum stress of o.85 f_{cup} (minimum stress level $\sim$ o), crack growth at early stages of cycling was mostly interfacial. A considerable increase in cracking was observed at stages close to failure. Wide cracks, similar to those seen in the short-time tests, appeared immediately before failure. For sustained load tests at o.85 f_{cup} mortar cracking was already observed at early stages of sustained loading. In addition, there was a marked increase in the extent of cracking at late stages of loading.

The nature of crack growth for cyclic tests on sawed specimens at o.95 f_{cup} was similar to that of cyclic tests at o.85 f_{cup}. In both cases the initial application of loading caused considerable cracking with some cracks extending into the mortar phase. Close to failure crack increase was significant, and also wide cracks developed.

For specimens with surfaces as-cast surface crack growth under load was related to voids, both with regard to new cracks and to the extension of existing cracks. Orientation of new cracks, as well as extension of existing cracks was close to the loading direction. Linking of cracks at late stages of loading was mostly limited to cracks located along a nearly common straight line. At failure, wide cracks of the type previously mentioned, were observed.

In Fig. 2 the relation between relative stress and total crack length of the traced area of a short-time test is given. The same figure shows the crack length at failure for sustained and cyclic tests at different maximum stress levels.

It was found that, in general, the macroscopic crack patterns at failure were very similar for cyclic, sustained, and short-time loading. In most cases a considerable number of wide cracks was observed in the vertical surfaces of the prisms. Most of these cracks had an average orientation close to that of loading. For the majority of specimens, long and wide inclined cracks, which almost invariably occurred in pairs, were also observed (Fig. 3). The average orientation of such inclined cracks varied between 2o^{o} and 3o^{o} with respect to the direction of applied load. In some tests the wide cracks coincided with the photographed surfaces; this provided an opportunity to observe the formation of these cracks. For specimens with sawed surfaces, the history could be traced back to smaller cracks which progressively linked to form the large and wide cracks.

These tests ascertained the existence of cracks in concrete before loading (1,5). They demonstrated that for short-time tests the transition from local interface cracking to the more extensive mortar cracking occurs at stresses in the neighborhood of o.85 to o.95 f_{cup}. Also the progressive alignment of cracks with the direction of loading, as loading is increased is in agreement with other studies (3,5,2).

Although most wide cracks were vertical, almost invariably, pairs of wide inclined cracks were found at failure. Similar observations had been reported in (3,5,6,14,15,19). What merits further discussion is not the fact that they exist, but what makes them come about.

The formation of wide inclined cracks immediately before or at failure suggests that failure will occur as soon as a continuous inclined crack surface is formed (see Fig. 3). Some investigators have tried to use theories of planes of least resistance, such as Coulomb's internal friction approach, in an attempt to explain this behavior. Others (3,6,12,15) have attributed their existence solely to the end restraint proveded by stiff loading platens. However, the work of Kupfer, et al (21) and Richart, et al. (5) reinforce the writers' belief that the formation of an inclined failure surface is a fundamental form of failure and not only a consequence of end restraint. Kupfer, et al (19) used special loading platens, which provide very little restraint, yet they observed that major inclined cracks, at approximately 3o^{o} to the applied load, appeared at failure for uniaxially loaded specimens. Furthermore, failure of cement paste cylinders occurs by progressive spalling of thin vertical sheets even when they are tested with stiff platens (Fig. 4).

III. Failure Model

On the basis of previous investigations and the observations described in the previous sections, the following conceptual model of crack propagation in concrete is proposed:

(a) Microcracks form initially at mortar-aggregate interfaces; most of these cracks are inclined with respect to the direction of loading. Under load, the interface cracks propagate into the mortar, preferentially in the direction of the applied load. The cracks, however, follow the weakest surfaces of the system.

(b) Progressive formation of microcracks leads to a system composed of a large number of small concrete elements which are separated by cracks with a predominantly vertical orientation.

(c) Failure, however, does not occur by progressive failure of the small individual elements, but by the joining of small cracks to form one continuous, inclined fracture surface.

This failure concept is different from Coulomb's approach, since it conceives failure as a consequence of progressive cracking, while Coulomb's approach assumes sudden failure to occur along a given plane when a limiting shear stress is reached.

The question to be answered is how and under what conditions inclined fracture surfaces form from individual microcracks.

Therefore, the interaction of cracks was studies to describe the conditions under which small individual cracks join to form one major crack.

IV. Model Study of the Mechanics of Crack Propagation and Failure in a Compression Field

An analytical study was undertaken to determine the validity of the proposition that crack interaction is the primary cause for the formation of inclined failure surfaces in concrete, and to determine the conditions which may lead to the formation of such a surface.

The analytical model consisted of inclined frictional cracks in a homogeneous, isotropic, and linearly elastic, two-dimensional infinite body. Here, frictional cracks are understood to be cracks which can transmit forces across and parallel to their surfaces. Only straight cracks were considered. The model is shown in Fig. 5.

Cotterell (21) proposed that a crack will propagate in the direction which maximizes the strain energy released as a result of crack extension. For a crack, such as the one shown in Fig. 6, further extension were to move along curve $\eta = \eta_o$ from O to P. It can be shown (22) that under these conditions the energy released is given by

$$U_d = (U^O - U^P) = \int_O^{\xi} \left[\sigma_\eta (u_\eta^+ - u_\eta^-) + \tau_{\xi\eta}(u_\xi^+ - u_\xi^-)\right] d\xi \qquad (1)$$

where U_d = strain energy released upon extension from O to P.

U^P, U^O = strain energy of system at P and O, respectively

σ_η, $\tau_{\xi\eta}$ = stresses that exist on OP when crack is at O;

σ_η is the axial stress normal to the η curve,

$\tau_{\xi\eta}$ is the shear stress along the same curve

$(u_\eta^+ - u_\eta^-)$, $(u_\xi^+ - u_\xi^-)$ = the relative displacements of the crack surfaces on OP when the crack is at P.

For the energy released to be a maximum the first derivative of eq. (1) must be equal to zero, and the second derivative must be negative.

Suppose that there is a single frictional crack of length, 2c, inclined at an angle ϕ as shown in Fig. 5. The body is loaded uniaxially with a stress σ_1. When σ_1 is transformed into equivalent boundary stresses in the planes parallel and normal to the crack, the following stresses are obtained:

$$\sigma_\phi = \sigma_1 \sin^2\phi \tag{2}$$

$$\sigma_{\phi+\pi/2} = \sigma_1 \sin^2(\pi/2+\phi)$$

$$\tau_{\phi,\phi+\pi/2} = \sigma_1 \sin\phi \cos\phi$$

Since it was postulated earlier that stresses can be transmitted across and parallel to the crack surface, a normal stress σ_ϕ and a frictional stress $\mu\sigma_\phi$ will be generated at the crack.

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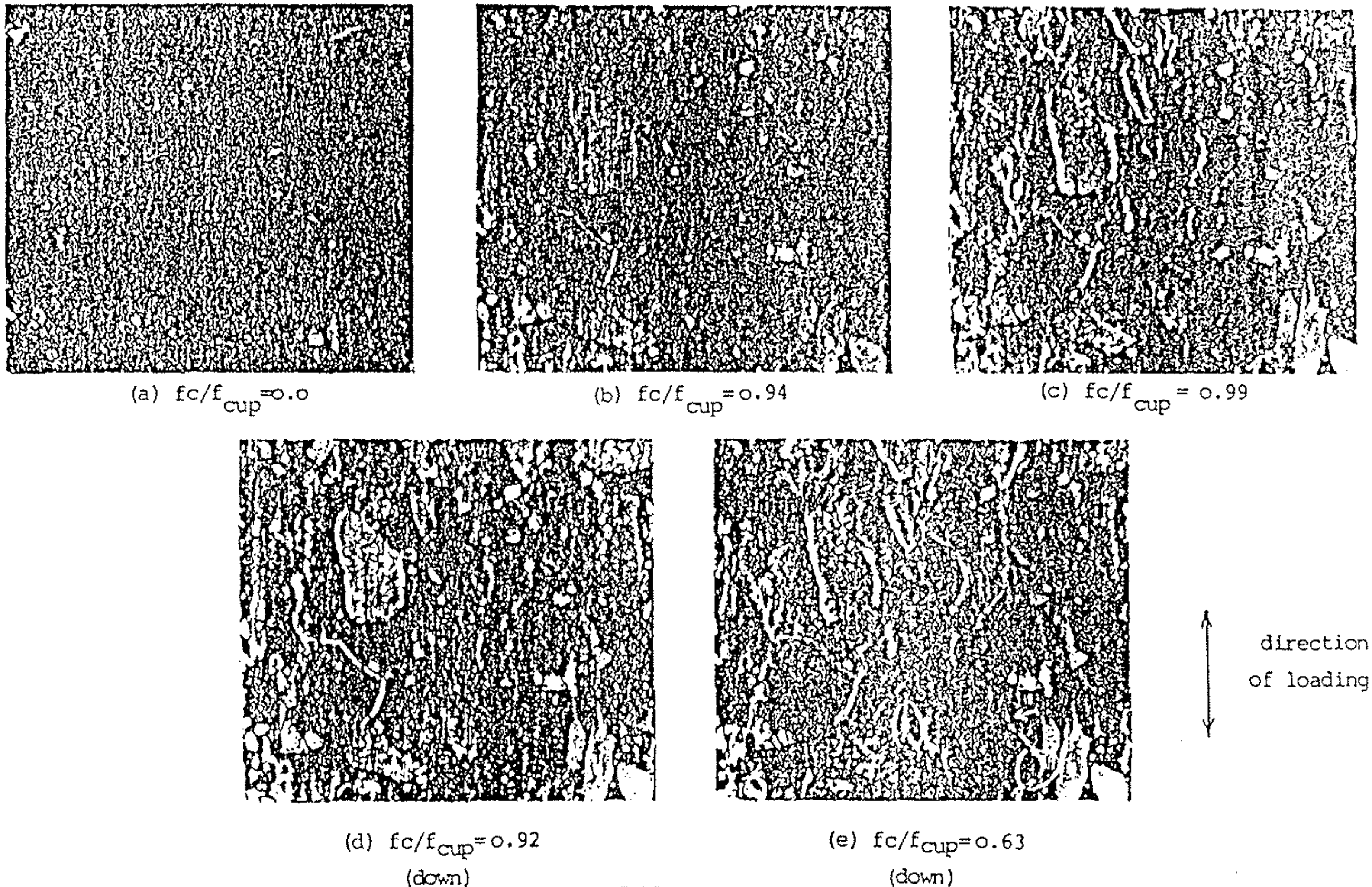


FIG. 1

Surface cracking at different stages of loading; short-time test, sawed surfaces

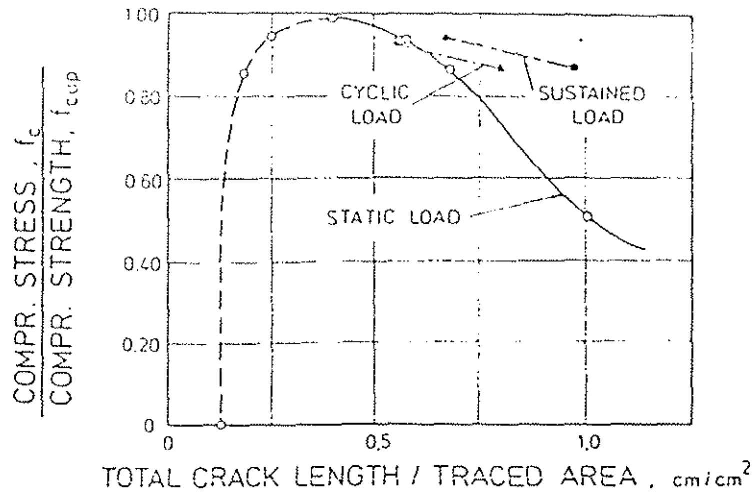


FIG. 2
Crack density on concrete surfaces

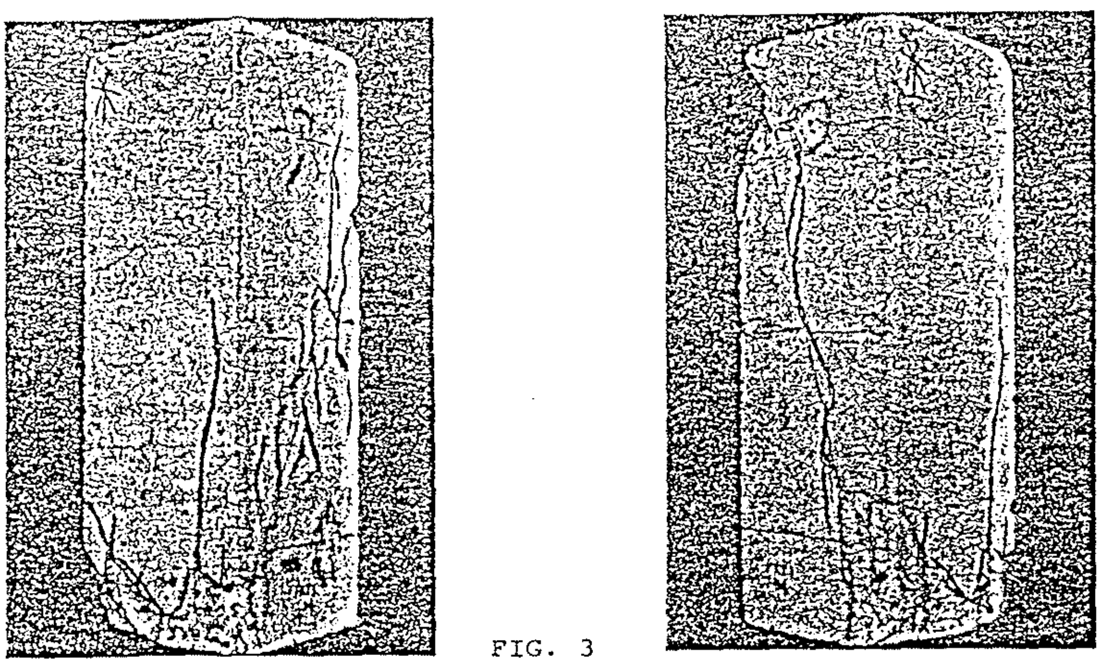
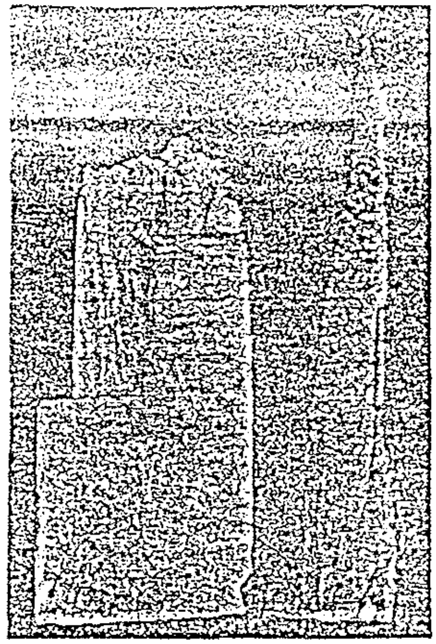


FIG. 3

Concrete specimens after failure with inclined cracks on parallel surfaces

FIG. 4
Cement paste cylinders after failure



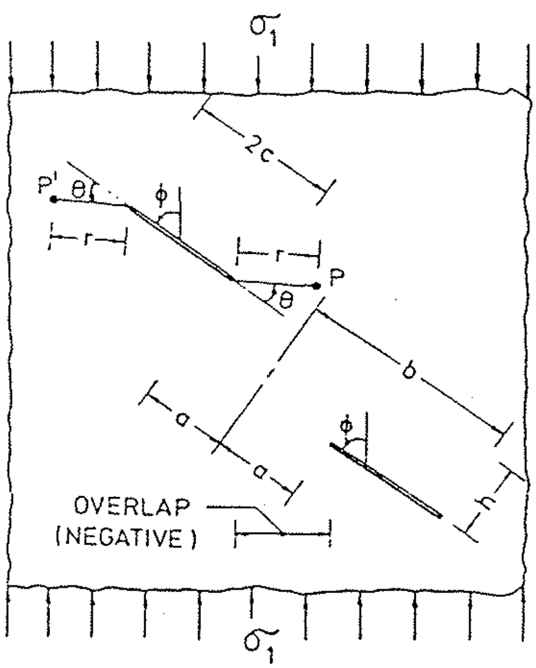


FIG. 5
Definition of crack parameters

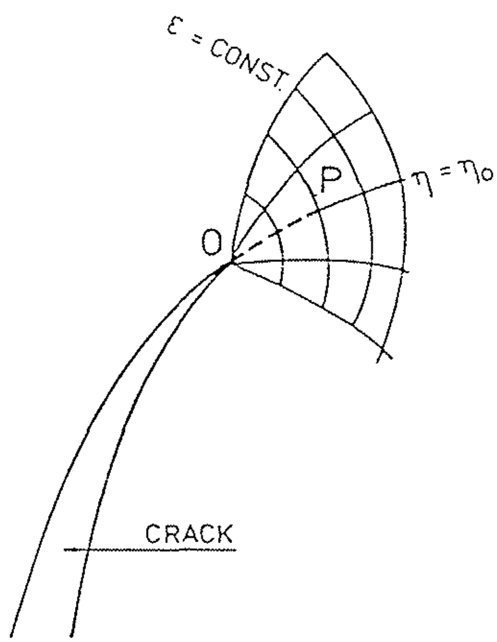


FIG. 6
Extension of a crack

GOI'S MAJOR PROGRAM FOR UPGRADING/CONSTRUCTING RURAL ROADS THROUGHOUT INDONESIA

by
Robert L. Brickner

JOINT UNPAR - ASCE SEMINAR
ON
THE STATE OF THE ART OF
CIVIL ENGINEERING PRACTICE
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Bandung, 18 May 1991
Parahyangan Catholic University

COMMENTS ON INTERNATIONALLY FUNDED PROGRAMS FOR ASSISTING KABUPATENS TO CONSTRUCT, UPGRADE & MAINTAIN RURAL ROADS THROUGHOUT INDONESIA

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President
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International Group in Indonesia

COMMENTS ON INTERNATIONALLY FUNDED PROGRAMS FOR ASSISTING KABUPATENS TO CONSTRUCT, UPGRADE & MAINTAIN RURAL ROADS THROUGHOUT INDONESIA

A PRESENTATION FOR THE JOINT UNPAR/ASCE SEMINAR ON 18 MAY 1991
AT THE UNIVERSITY OF PARAHYANGAN IN BANDUNG, WEST JAVA, INDONESIA

By Robert L. Brickner, P.E., F. ASCE
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I. Introduction

Although there is a lot of Government of Indonesia (GOI) construction going on that is well publicized such as the Jasa Marga tollways, airports, hydroelectric dams, deepwater ports, etc., little has been said about the rather unglamorous work of building local roads in the Kabupatens.

Yet, the Government realizes these roads have a great bearing on the country's advancement and as such a very large amount of money is now being spent to construct, upgrade and maintain such roads. This is not very well known even by we civil engineers, to say nothing of the general public.

For example, does anybody in this audience have even the slightest idea about GOI's Rural Roads Programs - how many kilometers (Km) of roads, meters of bridges, amount of money, number of consulting firms, etc. are involved?

Which GOI organizations are participating and what are their responsibilities, which international funding agencies have provided assistance, who is in charge of controlling the work, what is the role of the consultants, where has the work been done, when did the Rural Roads Programs begin, what are the plans for the future? And, for that matter, due to vast size of this program which will be continued far into the future, is it possible that you will eventually be a part of it?

Let us now learn the answers to these questions and obtain a general understanding of GOI's Rural Roads Programs which is having such a major bearing on Indonesia's present and future economic conditions as well as its basic infrastructure.

II. Background, Objectives & Basic Organization

Up until the late 1970's the majority of funds for designing/contructing roads were being used at the provincial/state level, with only a relatively small amount of money being available for local (Kabupaten) roads. But, since GOI realized that local roads contribute foremost to rural development and secondly to a balanced distribution of national income, it was decided to start upgrading such roads.

From this point of view, a local road development program was introduced in the Third Five-Year Development Plan (PELITA III, 1979/1980 to 1983/1984) as one of the main policies of the Government. Later, the objectives for the road sector under REPELITA IV (1984/1985-1988/1989) were instigated and consist of the following:

- To enhance economic development in rural areas.
- To provide better mobility to rural areas.
- To increase accessibility of isolated areas by the provision of all-weather roads.
- To strengthen the capability of the Kabupaten staff to plan, contract, construct and maintain their road networks.
- To introduce suitable techniques and work methods for the construction and maintenance of local roads.

Now, REPELITA V (1989/1990-1990-1994) has further extended the emphasis of REPELITA IV in addition to including the following objectives:

- To increase the export of non-oil commodities and agricultural products.
- To enhance tourism and home industries as a result of Kabupaten roads network improvements.
- To further open up isolated areas within the Kabupatens.

Work on the Kabupaten roads was first started with the financial assistance of the IBRD, ADB & OECF funding agencies in the early 1980's, with USAID beginning its participation in the late 1980's. These international funding agencies usually provide about 65% of the funds needed for the work, with the balance being furnished by GOI.

Taking into account all of the work done on the IBRD, ADB, OECF & USAID projects since full inception of the Rural Roads Programs in the mid-1980's, a large amount of funds has been and will continue to be spent on the Kabupaten roads. See Chart #1 for Summary of Internationally Funded Programs for Kabupaten Roads. The spending of about US$ 1.3 billion to construct over 114,000 km of roads and 76,000 meters of bridges is, I think you'll agree, very impressive.

And now another question comes to mind. How many Km of Kabupaten roads exist in Indonesia today and how does this amount compare to the better known State roads and Provincial roads - does anybody want to make a guess? It might surprise you. See Chart #2 listing the kilometers of State, Provincial & Kabupaten roads.

As can be seen, starting in 1980 the Kabupaten roads have increased at a much greater rate than either the Provincial roads or State roads, and there is already 4 times as many Kabupaten roads as there are Provincial roads. Moreover, the number of Kms of rural roads continues to grow at a fast rate.

The GOI organizations involved in the Rural Roads Programs are: Ministry of Home Affairs (Directorate of Regional Development), Ministry of Public Works (Directorate of Highways), Bappenas and Ministry of Finance (Directorate of Budgets). The work by these four organizations is coordinated by a Steering Committee made up of one senior person from each organization.

Implemention is the responsibility of DGRD, with technical assistance being provided by DGH.

A Project Management Unit (PMU) has been established to act as GOI's main operational/control/coordination organization.

At the Provincial level, the Governor, Bupati (Head of Kabupaten), Bappeda I (Planning), DPUP (DGH) and Kanwil all support the DPUKs located within the Province. The key word here is support - it is the DPUK which has direct responsibility for performing the work.

See Chart #3 to show how the Project is to be implemented. Also, refer to Charts #4, #5, #6 & #7 for showing the organization of DGRD, DGH, DPUP/Kanwil & DPUK, respectively.

International Consultants (civil engineers & mechanical engineers for equipment) are being utilized to assist the GOI organizations in Jakarta and at the Province/DPUK, while Indonesian Consultants (civil & mechanical engineers) are assigned to assist at every DPUK. Also, 1-2 DGH engineers have been seconded to each DPUK to act as the Chief Inspector(s).

How do all of these GOI organizations, International Consultants and Indonesian Consultants work together? It's a bit complicated to explain so let us look at Charts #8, #9 & #10 pertaining to implementation of the ADB 8th Road Project (Overall and at Bali & NTB Provinces).

Rural Roads are of 2 main types: roads to have asphalt sealing, and roads to be gravelled. Mostly this involves the upgrading of existing roads, but there is also new construction being performed.

Other main items of work are: bridges, raising of grade to prevent innundation during flooding, drainage ditches, culverts and slope protection.

III. Feasibility Study

As you may well know, almost no road project is undertaken without a feasibility study having been made. This is necessary to determine what the existing condition is, what the estimated future traffic is, what work items should (and should not) be included, how long it will take to perform the work, what the design parameters are, what type of equipment will be needed and of course the big question of what the estimated costs are for each main activity of the project.

In order to give you an idea about how feasibility studies are now being conducted, the following data is offered. It is based on the Overseas Economic Cooperation Fund of Japan's (OECF) Feasibility Study for the Local Road Development Project II at 39 Kabupatens in 10 Provinces (specifically for Tabalong Kabupaten at Kalimantan Selatan Province). There are several interesting facts/figures pertaining to what one can expect to find in a rather typical Kabupaten far away from the main areas of Sumatra, Java & Bali.

1. General Items for a Typical Road Feasibility Study

   A. Topographic and Meteorological Conditions (94 rainy days totalling 1,947 mm of rainfall).

   B. Socio - Economic Conditions

      1) Population Study

      2) Use of Productive Land (20% of total of 394,600 ha)

         a) Agricultural Harvest Area (ha of paddy field, ha of plantation, etc.)

         b) Residential & Industrial Areas

         c) Open Space

      3) Agriculture Production (cultivated area and food crops)

      4) Other Economic Activities (forestry, fishing, etc.)

   C. Present Status of Kabupaten Roads

      1) Outline of Road Networks

      2) Road Inventory (434 Km)

         a) Density (1.10 m per ha)

         b) Existing Type of Road Surface (asphalt 7%; gravel, Telford, & macadam 25%; and earth 68%)

         c) Findings of Surface Condition of Roads (Kabupaten and Province compared to Java & Indonesia as a whole).

Item	Good	Fair	Poor	Bad
Kabupaten Tabalong	16%	13%	41%	30%
Kalimantan Selatan	26%	34%	31%	9%
Java Island	46%	30%	19%	5%
Indonesia	43%	22%	21%	14%

As can be seen, there are about twice as many poor roads and six times as many bad roads in Tabalong Kabupaten in comparison to Java Island.

d) Terrain Conditions of Roads (flat 49%, hilly 24%, mountainous 21% & swampy 6%)

3) Bridge Inventory (timber 96%, concrete 1%, steel 3%)

4) Average Daily Traffic Counts (cars 7%, buses 1%, trucks 12% & motorbikes 80%)

2. <u>Estimate of Future Traffic Volume & Benefits</u>

A. Traffic Growth Rate (determined by economic formula based on growth rates of population, agriculture & GDP/Capita)

B. Benefit Estimation Method (based on vehicle operation cost)

3. <u>Engineering</u>

A. Design Criteria

1) Geometric Design Criteria

This is based on DGH's Petunjuk Teknis Inpres Penunjangan Jalan Kabupaten, Tahun 1984 - 1985). It is also based on Road Classification (IIIA, IIIB-1, IIIB-2 & IIIC), Surface Type, Traffic Volume & Terrain.

Note: The average design width of road is 3.5m to 6.0 m plus 1.0 to 2.0 m shoulders, depending on road classification and type of terrain.

2) Loading Specifications for Bridges

These are established by DGH. The design live load for bridges on Kabupaten roads is 50-70% of the the DGH live load.

B. Pavement Design

1) Design Conditions

a) Design Traffic Volume

There are four main ranges of traffic volume (1-49, 50-200, 201-500 & 500-3000 vehicles/day)

b) CBR Strength of Roadbed

This is normally based on a CBR that is in the range of 4 - 10%, but actually it should be determined in the field as this is a most important design item.

2) Pavement Structure (depends on Road Classification)

a) Surface (Lapen - 5cm, DBST - 5cm or SBST - 3cm)

b) Base Course (crusher run rock with filler)

c) Subbase Course (sandy gravel)

C. Design of Bridges & Other Structures

1) Standard Bridge (based on DGH Standards)

a) Superstructure

b) Substructure

c) Foundation (based on soil borings)

2) Culverts

a) Reinforced Concrete Pipe (0.80 m diameter)

b) Box (stone & mortar walls with reinforced concrete slab)

3) Retaining Walls

a) Stone and mortar

b) Timber

4) Ditches

a) Lined (Trapezoidal-shaped consisting of stone and mortar)

b) Unlined (Vee-shaped)

D. Considerations for Selection of Types of Equipment

1) Whether the work is of an equipment intensive type (earthwork, base course & subbase course), or a labor intensive type (surface, drainage, bridges, culverts & retaining walls)

2) Most of equipment will be used for road construction

3) Narrow pavement width will restrict the size of equipment

4) Uniformity of equipment is important

5) Rely more on wheeled equipment for ease of movement

E. DPUK Workshop

1) Administration for and storage of equipment

2) Routine Maintenance and light repair of equipment

3) Storage and supply of spare parts

4) Operation of equipment

5) Type of workshop equipment and tools needed

F. Laboratory & Surveying

1) Laboratory Equipment

a) Soil Moisture Test Set
b) Liquid Limit Set
c) Plastic Limit Set
d) Compaction Set
e) CBR Laboratory Set, Mechanical
f) Sand Density Apparatus
g) Aggregate Test Sieve Set
h) Portable Cone Penetrometer
i) Compression Testing Machine for Concrete Moulds
j) Cylinder Mould
k) Slump Test Apparatus

2) Surveying Equipment

a) Transit
b) Level
c) Tapes
d) Rods
e) Compass

4. Construction & Maintenance Cost Estimations

A. Determination of Unit Prices (Labor, Materials & Equipment)

B. Determination of Unit Construction Costs by Work Type (clearing, subgrade, fill, subbase course, base course, asphalt, shoulders, bridges, culverts, etc.)

C. Determination of Routine Maintenance Cost per Km for Type of Road (earth, gravel or asphalt)

5. Results of Economic Feasibility Evaluation

A. Preliminary Screening (delete unfeasible roads)

B. Evaluation of Accumulated Data to make Analysis

1) Primary Analysis (Internal Rate of Return is to be over 12%)

2) Secondary Analysis (consider roads having an IRR of 8 - 12%)

3) Ranking of Feasible Links

6. ImplementatinnProgram

A. Estimated Project Costs

Once all of the collected data has been evaluated, the total estimated project cost can be determined for each main type of work. These cost have to be divided in to a foreign portion and local currency portion per the following example:

Type of Work	Foreign currency	Local currency	Total Est. Cost
Construction			
Maintenance			
Workshop Equipment & Tools			
Laboratory Equipment			
Survey Equipment			

B. Proposed Roads to be Worked On

After all of the costs have been determined, the roads to be worked on will be selected and listed as follows:

a) Roads to be Improved (link number, length of km, width in m, type of surface, length of bridges if applicable and estimated cost)

b) Roads to be Maintained (by link number and estimated cost)

The preparation of the feasibility studies for the Rural Road Programs have been done by international consultants in association with Indonesian consulting firms and usually take about 12-18 months to complete. Once a study is submitted to GOI and the funding agency, a decision is made about what to do and a loan is signed. This opens the way to start the Implementation Phase of the project, which will now be discussed.

IV. Implementation Phase

1. Typical Project Scope (on-going OECF Program in 30 Kabupatens)

A. Civil Works

1) Improvement of selected primary Kabupaten roads, including upgrading of existing road pavement,bridges, drainage structures etc., and the construction of additional Kabupaten roads. The work should be done on a tender basis (local competitive bidding).

2) Maintenance of selected Kabupaten roads (depending on the type of Program).

B. Supplementary Procurement of Equipment

1) Procurement of maintenance equipment, spare parts and other equipment required for the implementation of the civil works.

2) Procurement of laboratory & survey equipment for each DPUK.

C. Consulting Services

1) To provide technical assistance and support for DPUK staff concerning the design, DURP/tender and supervisory services of the improvement works to be done by the contractors.

2) To provide advisory services for operating and maintaining equipment by DPUK operators and mechanics.

3) To provide overseas training for DPUK and Bina Marga technical and management staff (depending on the type of the Program).

2. General Nature of Consulting Services Required

See Charts #11 & #12 listing responsibilities and basic organization for on-going OECF Program.

3. Detailed Scope of Consulting Services Required

See Charts #13, #14 & #15 listing duties of typical Core Team, Sub Teams & Supervisory Teams for on-going OECF Program.

4. Staffing Schedule

See Charts #16 & #17 showing typical numbers of expatriates and local consultants, and period of main work activities.

5. Procure Equipment for DPUK Workshops & Laboratories.

   See Charts #18 & #19 showing typical equipment delivery flow and types of equipment.

6. Establish Standard Specifications by Consultants (based on existing DGH Standards).

7. Field Engineering Investigation & Survey

   A. Determination of CBR for subgrade
   B. Soils & materials testing
   C. Drainage systems
   D. Borrow pits/quarry sites
   E. Basic surveys.

8. Design Activities

   A. Design Criteria (see Chart #20 listing standard design criteria for Kabupaten roads)

   B. Standard Road Cross Sections (see Chart #21 showing typical cross sections for each class of road)

   C. Roads

      The design class for a local road is based on the projected number of single axle loads per traffic lane over a 10-year life as well as the CBR of the subgrade. Data relating to the types of surface and roadbed are described as follows:

      1) Type of Surface

         The type of surface is be based on the average daily traffic (ADT) projected in 5 years and the Road Classification (IIIA, IIIB-1, IIIB-2 & IIIC). This consists of two types of surfaces listed below:

         a) Base course material (well graded, crushed rock with filler) is usually used for traffic up to 200 vehicles per day (vpd)

         b) SBST/DBST/Penetration Macadam for traffic over 200 vpd; however, it should be pointed out that hot-mixed asphalt surface can be used in special cases when justified by means of an Economic Internal Rate of Return (EIRR) Study

            Note: Based on my experience, it is better to keep the base course type of surface to a minimum and instead place an inexpensive asphalt seal on roads having an ADT of 50-200 vpd. Moreover, steep grades in mountinous/hilly areas should always be sealed. Even though this will cost a little more at the time, in the long run it will save a lot of money.

2) Type of Roadbed

a) Good conditions are considered to be present when the CBR of the subgrade is over 24%. This will require only 10-20 Cm of base course being placed (no subbase), depending on the design class

b) Fairly good conditions if the CBR is 8% to 24% (requires 10-20 Cm of base course plus a minimum of 10 Cm of subbase)

c) Weak conditions if the CBR is 5% to 7% (requires 10-20 Cm of base course plus 15-20 Cm of subbase)

d) Poor conditions if the CBR is 3% to 4% (requires 10-20 Cm of compacted embankment fill plus subbase and base)

e) Very poor conditions if the CBR is 1.5% to 2% (requires 30-50 Cm of compacted embankment fill plus subbase and base).

Note: Specific thicknesses of base, subbase and embankment fill depend on the design class (number of Single Axle Loads per traffic lane projected over 10-year period).

D. Bridges

1) Reinforced concrete type will follow DGH standards; however, when necessary core borings must be taken to determine what type of foundation is required.

2) Timber type (see Chart #22 showing typical cross section).

E. Culverts (see Chart #23 showing typical cross sections)

1) Stone and mortar with reinforced concrete slab (minimum 80 cm x 80 cm)

2) Reinforced Concrete Pipe (minimum 80 Cm in diameter)

F. Retaining Walls (see Chart #24 showing typical cross sections)

1) Timber

2) Stone & mortar

9. Prequalification of Contractors

A. Contractors within the Province are classified in a booklet prepared by the Governor's office called the DRM.

Classifications range from A (large contractors), to B-1 & B-2 (medium contractors), to C-1, C-2 & C-3 (small contractors).

B. Classifications are based on the contractor's record of accomplishments over the last several years, financial strength, type/condition of equipment, qualifications of supervisory personnel, total years experience, etc.

C. Contracts over Rp 500 million are to be done by Class A contractors, contracts in the range of Rp 300-499 million are to be done by Class B-1 contractors, contracts in the range of Rp 200-299 million to be done by Class B-2 contractors, etc.

D. Close attention must be paid to prequalification of contractors as it is the contractor who most always determines whether the project will be implemented properly or poorly.

10. Tendering/Awarding

A. Issue of tender documents to prequalified contractors (tendering forms, design drawings, bill of materials, conditions of contract, specifications, required equipment, schedule, etc.).

B. Usually about 2-4 weeks are allowed for tender meetings, site investigation, tender preparation and tender opening.

C. Tender evaluation is performed by the DPUK Tendering Committee and the prospective awardee is announced.

D. Approval of award is made by the DPUK Kepala, Kabupaten Bupati, Provincial Governor or in Jakarta depending on the amount of award. The Bupati can approve awarding contracts up to Rp 200 million and the Governor can approve awarding contracts of Rp 200-500 million, while the Ministry of Home Affairs has to approve awards over Rp 500 million.

E. The design and tendering activities should be done during the rainy season so the award can be made about the time the dry season is beginning.

11. Construction Stage

The construction stage of any project is the one which will have the greatest effect on it and will either result in the roads being built correctly or not. There are many issues to discuss pertaining to this but time limitation requires only the following salient points to be brought out:

(Note that during this part of the presentation, color slides will be shown to give you an idea of the type of construction practices now going on in the field).

A. General

As mentioned before, the most important thing in getting a well run project is to have a good contractor. Too often, a contractor is awarded a project but when it comes time to perform he does not have experienced supervisors, is short of suitable equipment and does not understand the necessity of quality control. That is why it is neccessary to eliminate such types of contractors by means of the prequalification process. Certainly very close attention should be paid to this.

B. Pre-Construction Meeting

This must be held to discuss all key items pertaining to the project, to make it clear what will be required, to explain how offical communications will be handled, to clarify the payment procedure, to emphasize quality control and to answer all of the contractor's questions. If this is not done, it's probable things will get off to a bad start and then stay that way.

C. Contractor's Key Personnel

It is essential that the contractor provides a capable project manager, site superintendent and chief mechanic. If a bridge is included in the contract the contractor must also have an experienced bridge foreman. Close contact is to be maintained with these people as they are the ones who will either get the work done properly or will allow problems to arise.

D. Types of Required Equipment

This will depend on the size of the project and terrain, but for an idea as to what equipment is desirable, refer to Chart #25. One of the biggest problems in constructing Kabupaten roads is the contractor's shortage of equipment.

E. Types of Materials

The main types of materials for the road are the subbase course, base course and asphalt pavement. See Chart #26 for a description of such materials. The DGH standard specifications for these materials is not difficult to meet and the contractor can do it - if he is required to. There have been some reported cases of shortages of asphalt and portland cement, but for the most part this has not been too big of a problem.

F. Supervision of Construction

This is where the maximum effort is needed by all parties. If it is not properly handled, one can be sure of low grade or even unsatisfactory end results which will cost the Government a lot of money and cause inconvenience to the public.

1) Inspection System

Each DPUK has 1-2 DGH engineers assigned to it who will act as Chief Inspectors. Also, every project will have at least one full-time inspector at the field site for each 5 Km of road. These are the people who must require the contractor to follow the specifications.

2) Laboratory Testing

All DPUKs are provided with a fully equipped laboratory and at least 4 laboratory technicians with access to a vehicle. Many types of tests for roads can be performed but the most important ones are for the CBR, Gradation and Density.

3) Consultant's Activities

There is one Highway Design & Construction Engineer assigned by the Consultants to each DPUK who is to give overall guidance. One of his main jobs is to make field inspections during the construction phase to spot-check on the quality of the work being performed. In addition, there are 1-2 consultants at each provincial capital who are also required to make field trips to check on the quality of the work and provide guidance.

4) Contractor's Supervisors

As discussed earlier, these are the people who will actually either make or break the quality control program. That is why the DPUK and Consultants must make sure the contractor's supervisors understand the importance of quality control, and that the contractor's work will not be certified (or paid) if it does not comply with the specifications. Generally speaking, the contractor's supervisors will do the work properly if they are so required; otherwise, it often will not be done.

5) Construction Procedures

The DPUK/Consultants are to assist the contractor to prepare construction procedures for each main work activity - then to ensure that the field supervisors and inspectors have copies of the procedures and that they are being followed. This will be of significant assistance in having the specifications met.

G. Construction Schedule

Usually, the contractor will fall behind schedule but this can be controlled if the DGH Chief Inspectors and Consultants are aware of what is happening and inform the contractor what he can do to overcome the problem.

If a contractor falls more than 15% behind schedule, weekly meetings are to be held for the purpose of preventing further delays, and the contractor will be required to submit a schedule to show his planned activities for the week. If the contractor falls even further behind schedule, termination of the contract can be considered, but frankly speaking once a contract has been awarded it is difficult to terminate it.

12. Contractor's Payments

A. The contractor is usually paid for each time he accomplishes about 25% of the work, with a certain amount being withheld to take care of any advance payment (20%) that may have been made. This means he will be paid about 4-5 times over the course of the contract's period which normally varies between 5-8 months.

B. The DPUK Chief Inspector and Consultant's engieneer assigned to the DPUK are to recommend whether or not a payment certificate (SPPP) is to be approved by the DPUK Pimpro. Once they have signed the SPPP, this means they are certifying that the work to be paid for meets the specifications.

So, this is a most important step and has to be taken seriously by all concerned. There have been some cases of Chief Inspectors signing a SPPP when the work does not comply with the specifications and this can result is a big problem later.

C. The approved SPPPs are then processed for payment. All payments are pre-financed by GOI, with the international funding agency reimbursing the Ministry of Finance (MOF) later after the work has been completed and certified. The GOI portion of the payment (usually 35%) can be directly paid to the contractor at the Province, but the internationally funded part is often paid to the contractor at Jakarta by the MOF through the Bank of Indonesia. See Chart #27 showing details on how the GOI portion is paid.

D. The Consultant's expatriate Highway Design & Construction Specialist (HDCS) at each Province is normally required to sign the last SPPP at the time of the Final Hand Over Inspection (FHO). By then, it is almost too late for him to observe any hidden defects, so this is why the DGH Chief

Inspectors and HDCE must have required the contractor to have done the work properly throughout the entire construction period.

13. Aceptance of Completed Road

A. When the contractor completes 97% of the work, the DPUK will hold a Provisional Hand Over Inspection (PHO) and require that all observed deficiencies be corrected.

B. When 100% of the work has been done and the observed deficiencies have been corrected, the FHO Inspection will be held. Persons making the inspection will include the DPUK Kepala, DPUK Pimpro, DGH Chief Inspector, Consultant's HDCS, Consultant's HDCE and contractor's key staff.

Also, the Kabupaten's BPP Committee will participate in the FHO Inspection. The DPUK/Consultants will certify the completed work from a technical viewpoint, while the BPP Committee will offically accept it on behalf of GOI.

C. Once the DPUK/Consultants have certified the completed project and the BPP Committee has accepted it, the Consultant's Team Leader can include the amount for payment (by the international funding agency) on a Withdrawl Application. This document is sent to the international funding agency's home office thereby authorizing it to reimburse the Ministry of Finance for the money that MOF has already paid to the contractor.

Note: The entire process for paying the contractors (by pre-financing) up through the international funding agency reimbursing the Ministry of Finance is quite complicated, as can be seen is Chart #28.

14. Maintenance

A. Maintenance by the Contractor

The contractor is required to maintain the completed road, but only for one month. After this, the DPUK will perform the two basic types of required maintenance - routine and periodic (see Chart #29).

B. Routine Maintenance

This involves work that is programmed in advance and performed by the DPUK in accordance with the established program. Much of it is labor intensive.

C. Periodic Maintenance

This type of work is more expensive and time consumming. It is performed when needed and requires availability of materials and equipment.

D. Financing & Performing Maintenance

Maintenance work is expensive and there are very limited funds available for doing it, but GOI realizes the importance of it and is taking steps to improve the situation.

One of the reasons the maintenance activities by the DPUKs have not been so successful is because there is a tendency for the supervisors to concentrate their efforts on other matters. This is to say nothing about it being difficult to control the expenditures for maintenance work. GOI will have to continue to try to get better results on the maintenance of the rural roads, both existing and those now being completed.

15. Monitoring of the Project

A. Project Management Unit (PMU)

The PMU has overall control of monitoring the project and is required to keep all of the involved organizations informed on what is happening.

B. Coordination Meetings

Depending on the project, monthly/bi-monthly or periodic meetings are held in Jakarta and/or the provincial capitals. These are attended by Bappenas, DGRD, DGH, MOF, PMU and the Consultant's Team Leaders. The important aspects of the project are throughly discussed and decisions are made on how to overcome problems.

C. International Funding Agency Inspections

The international funding agencies send missions to Indonesia about every 4-6 months to visit the project sites, coordinate with the involved GOI organizations/Consultants and offer guidance concerning pertinent matters.

All of the main aspects of the Rural Road Programs have now been discussed, so I will now make my concluding remarks.

V. Conclusion

You now know a lot more about what GOI is trying to accomplish on the major Rural Roads Programs being performed throughout Indonesia, and what has been done to have these programs be properly implemented.

With an estimated US$ 1.3 billion having already been spent/programmed to build over 114,000 Km of roads and 76,000 meters of bridges, nobody will doubt that GOI's Rural Roads Program is one of the largest and most important endeavors now being undertaken. And, who is to say what will be accomplished throughout the rest of this decade (century).

Since so much effort has previously been expended with good results on the higher profile projects such as provincial roads, dams, airports and other infrastructure items, emphasis can now be placed on upgrading the Kabupaten road networks. Considering that the majority of Indonesians are located in the rural areas, this is perhaps one of the best uses of infrastructure funding as it will have such a direct and immediate effect on these people's daily lives.

During this presentation, you have seen color slides showing the conditions of the Kabupaten roads before being upgraded and after. In this regard, I suggest that you try to picture yourself not as residing in a city, but rather living in a remote rural area located far away from even a provincial level road and what problems/hardship this will cause for you, your family and village neighbors. Then reach a decision as to how important this program is. I think there can be only one conclusion - it is absolutely the thing to do. Or, as my fellow countrymen say about such a situation which is being properly done and is having most positive results - Right On!

It is necessary to point out that the information I have passed on today is only of a general nature that has been arrived at as a result of my involvement in the ADB 8th Road Project and making many trips to the jobsite areas over the last four years - none of it is from official sources. Moreover, it is possible that there may be errors in some of the figures I have refered to; however, for the most part I believe the data presents a rather accurate view of what is currently being done to upgrade rural roads in Indonesia.

Finally, let me add that having been a civil engineer for 35 years, I have participated in many large and interesting projects throughout most parts of the so-called free world both in the military and in civilion life. In this regard, I very much like the fact I have been able to help build things that are of use to the public, but I have never been more satisfied to have been able to participate in an undertaking like this which has been of such benefit to the common man who is living in areas that can only be reached by rural roads. I am glad I have had the opportunity to have been a part of GOI's Rural Road Programs, especially in a country which has so many nice people and such bright prospects for the future.

Thank you most kindly for your attention. If there are any questions, please do not hesitate to ask them.

UNOFFICIAL SUMMARY OF INTERNATIONALLY FUNDED PROGRAMS FOR ASSISTING KABUPATENS TO CONSTRUCT, UPGRADE & MAINTAIN RURAL ROADS THROUGHOUT INDONESIA L1

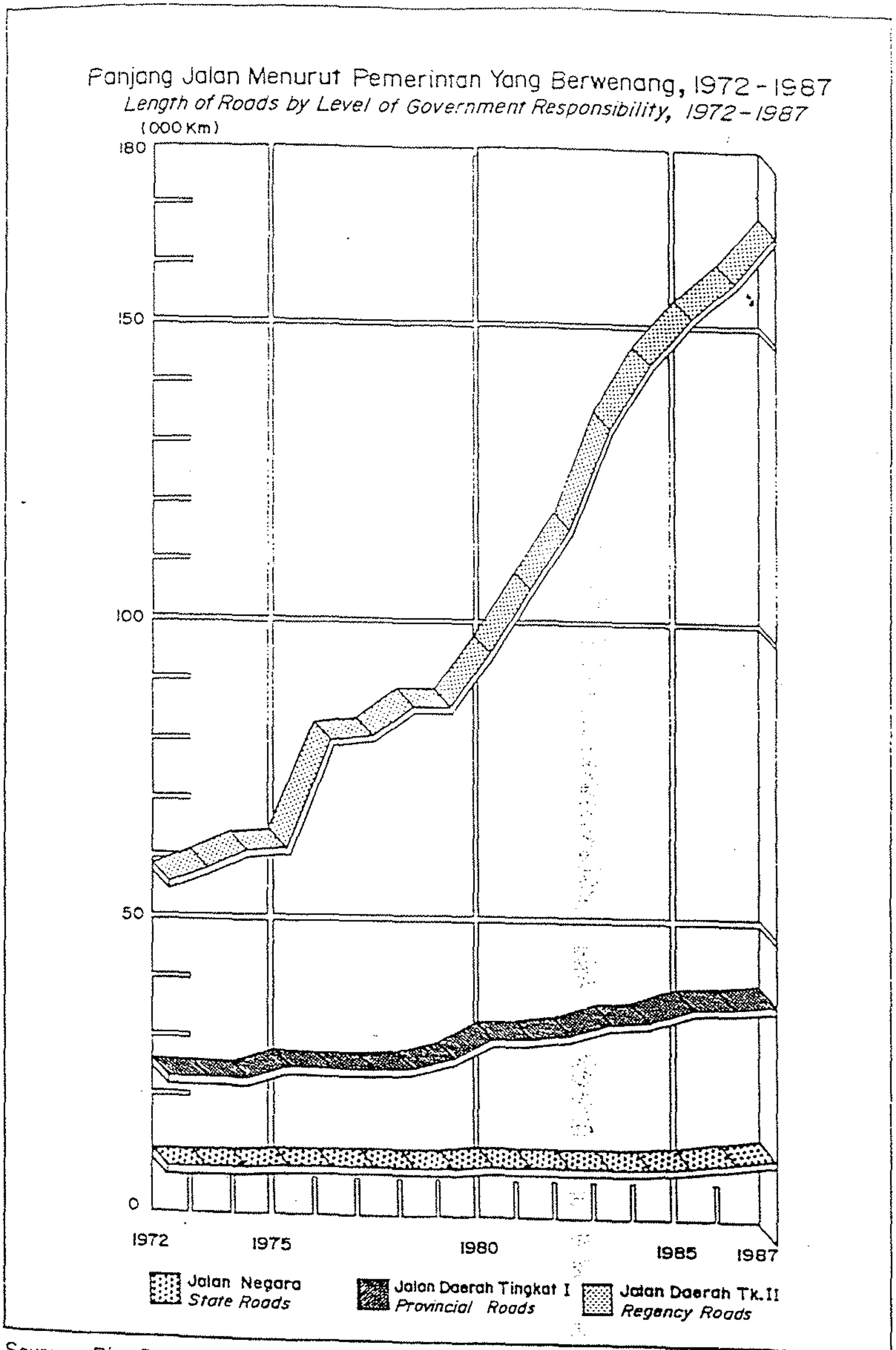
CHART # 1

GOI 5-Year Program	International Funding Agency & Project	Feasibility Study By Consultants & Dates	Road Length in Km (No. of Roads) L2	Bridges in M (No.Of. Br) L3	Estimated Costs ($)	Foreign Funds (% Of Total)	Local Funds (% Of Total)	International Consultants	No. of Local Consultants	Provinces (Kabupatens)	Const.Period (Fiscal Years)
Pelita III 79/80-83/84	ADB 6th Road Project, Rural Roads I Program	Hoff & Overgaard (DAN) 1980-1981	755 Km (150)	650 M (80)	$ 35 Million (100 %)	$ 23 Million (65%)	$ 12 Million (35%)	Delcux Cather (US)	2	2 (14)	6 Years (83/84-88/89)
Repelita IV 84/85-88/89	ADB 8th Road Project, Rural Roads II Program	Hoff & Overgaard (DAN) 1983-1985	5,500 Km (1,375)	5,100 M (450)	$200 Million (100 %)	$130 Million (65%)	$ 70 Million (35%)	BCEOM (FR) & NK (JPN)	4	4 (30)	5 Years (87/88-91/92)
Repelita V 89/90-93/94	ADB 12th or 13th Road Proj Rural Roads III Program L6	One (Proposed) 1992-1993	7,000 Km (1,400)	6,500 M (600)	$260 Million (100 %)	$169 Million (65%)	$ 91 Million (35%)	Two (Proposed)	6 (Proposed)	6 (40)	4 Years (94/95-97/98)
Pelita III 79/80-83/84	OECF Local Road Dev. Project II, Equipment Procurement	PCI (JPN) 1979-1980	N/A	N/A	$ 51 Million (100 %)	$ 33 Million (65%)	$ 18 Million (35%)	PCI (JPN)	N/A	10 L4 (38)	2.5 Years (82-83/84-85)
Repelita IV 84/85-88/89	OECF Local Road Dev. Project II	JICA (JPN) 1984-1986	22,224 Km (4,400)	27,000 M (1,300)	$132 Million (100 %)	$ 86 Million (65%)	$ 46 Million (35%)	PCI (JPN)	10	10 L4 (38)	3 Years (88/89-90/91)
Repelita V 89/90-93/94	OECF Local Road Dev. Project II A	JICA (JPN) 1984-1986	4,700 Km (950)	6,660 M (700)	$ 64 Million (100 %)	$ 42 Million (65%)	$ 22 Million (35%)	One (Proposed)	10	10 L4 (39)	2 Years (91/92-92/93)
Pelita III 79/80-83/84	IBRD Rural Roads I Development Project, Upgrading/Support	ENEX (NZ) 1980-1982	2,850 Km (650)	4,830 M (450)	$129 Million (100 %)	$ 84 Million (65%)	$ 45 Million (35%)	ENEX (NZ) N.D. LEE (CAN) L. BERGER (US)	3	5 L5 (25)	5 Years (82/83-86/87)
Repelita IV 84/85-88/89	IBRD Rural Roads II Development Project	Hoff & Overgaard (DAN) 1985-1986	-	-	-	-	-	H & O (DAN) RENARDET (SWISS) KAMPSAX (DAN) DHV (Dutch)	6	-	-
	Maintenance only		23,283 Km (4,500)	19,000 M (2,300)	$ 52 Million (100 %)	$ 17 Million (30 %)	$ 35 Million (70 %)			11 L5 (76)	4 Years (88/89-91/92)
	Rehabilitation		6,615 Km (1,300)	2,000 M (400)	$135 Million (100 %)	$ 47 Million (35 %)	$ 88 Million (65 %)			7 L5 (51)	4 Years (88/89-91/92)
	Equipt & Workshops		N/A	N/A	$ 54 Million (100%)	$ 47 Million (?)	$ 7 Million (?)			11 L5 (76)	4 Years (88/89-91/92)
Repelita V 89/90-93/94	IBRD Rural Roads III Development Project	Hoff & Overgaard (DAN) 1991-1992	40,000 Km (7,000)	3,500 M (375)	$200 Million (100%)	$130 Million (65%)	$ 70 Million (35%)	Four (Proposed)	6 (Proposed)	12 (110)	4 Years (92/93-95/96)
Repelita IV 84/85-88/89	US AID Rural Roads Maintenance System (75% maint. & 25% Const.)	Parsons (US) 1986-1987	1,200 Km (300)	1,000 M (120)	$ 78 Million (100 %)	$ 55 Million (65%)	$ 23 Million (35%)	SIV/Lyons (US)	1	2 (9)	8 Years (87/88-94/95)
		Approx Totals (Actual) :	67,127 Km (13,625)	66,240 M (5,800)	$ 930 Million (100 %)	$564 Million (61%)	$366 Million (39 %)	13 L7	32 L7	29 L7 (167)	36.5 Years cumulative (82/83-94/95)
		Approx Totals (Proposed):	47,000 Km (8,400)	10,000 M (975)	$ 460 Million (100%)	$299 Million (65%)	$161 Million (35 %)	6	12	18 (150)	8 Years cumulative (92/93-97/98)
		Approx Grand Total	114,127 Km (22,025)	76,240 M (6,775)	$1,390 Million (100%)	$863 Million (62%)	$527 Million (38 %)	19	44	47 (317)	44.5 Years cumulative (82/83-97/98)

Notes:

L1 : All figures and data are only approximate and are based on unofficial sources.
L2 : Length of each road varies from 1 km to 10 km, but average length is about 4-6 km.
L3 : Length of each bridge varies from about 6 m to 40 m, but average length is about 8-12 m.
L4 : Same Provinces and Kabupatens
L5 : Same Provinces and Kabupatens
L6 : Only in the initial concept stage, so listed data is roughly estimated.
L7 : Non-cumulative

feasib-apr/wk1

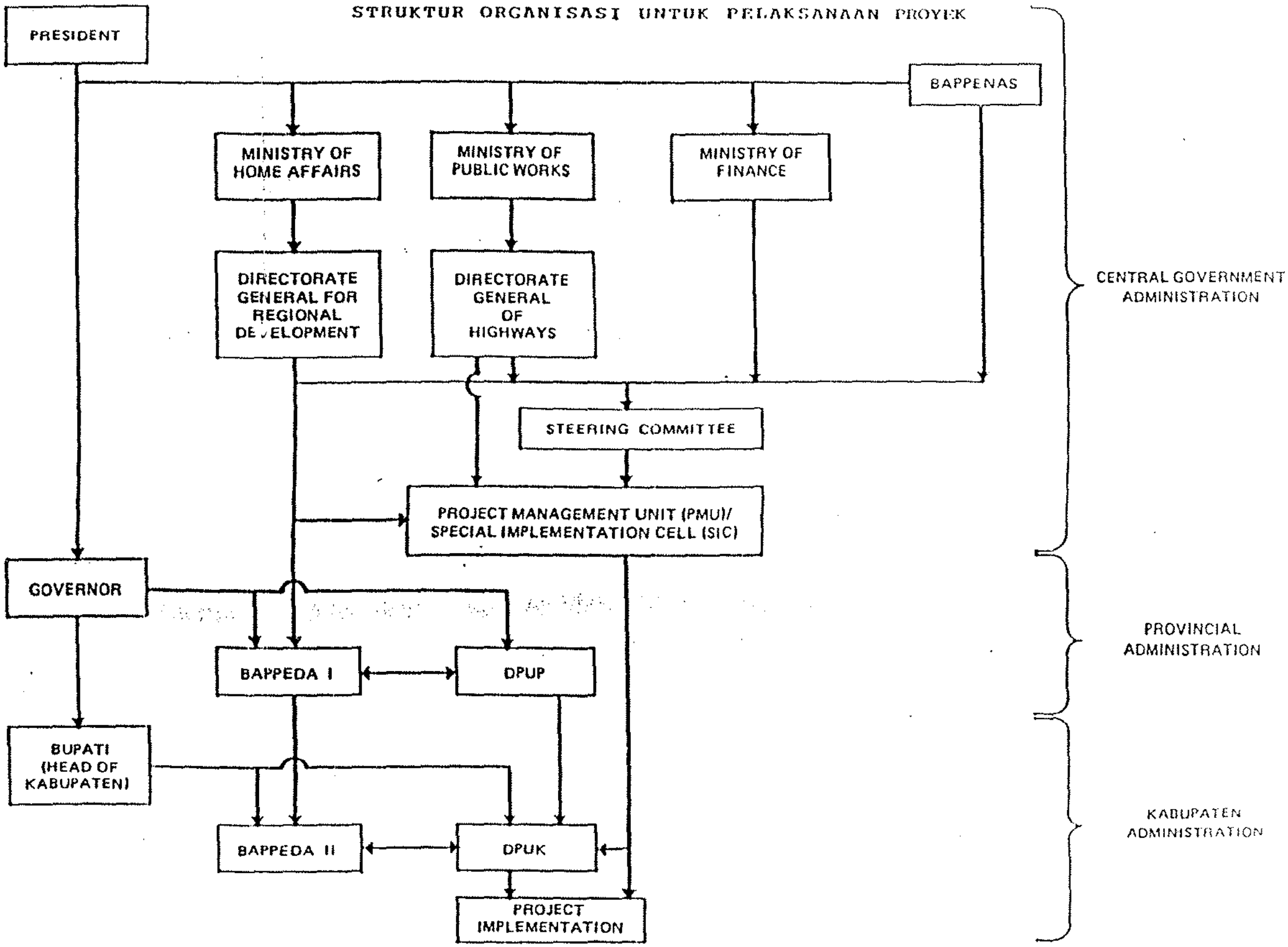


Source : Biro Pusat Statistik , Statistik Indonesia 1989 , p.401

CHART # 3

ORGANIZATIONAL CHART FOR PROJECT IMPLEMENTATION

STRUKTUR ORGANISASI UNTUK PELAKSANAAN PROYEK



CHART

ORGANIZATIONAL STRUCTURE OF DIRECTORATE GENERAL FOR REGIONAL DEVELOPMENT (DGRD)

STRUKTUR ORGANISASI BANGDA (BADAN PELAKSANA)

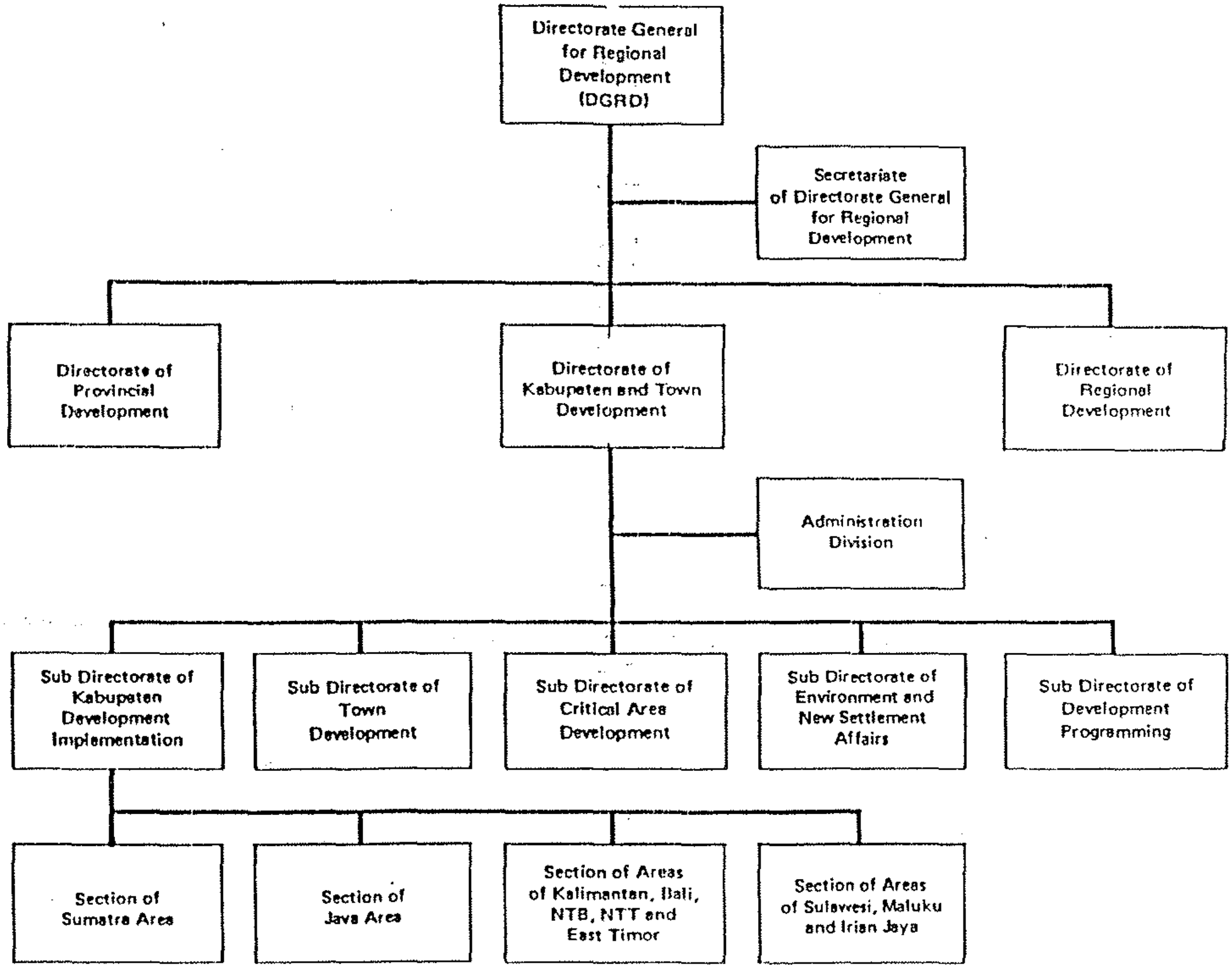
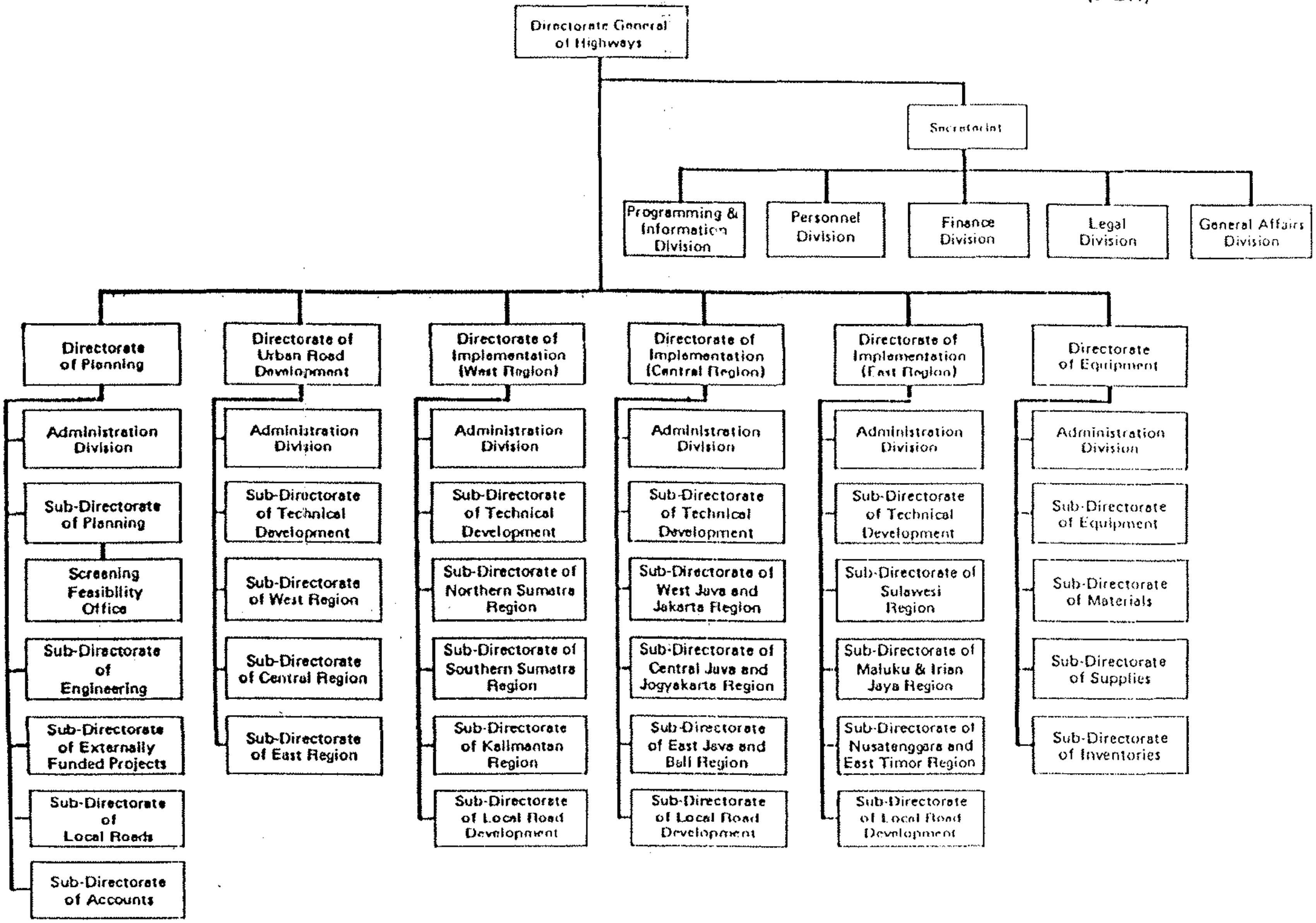


CHART A

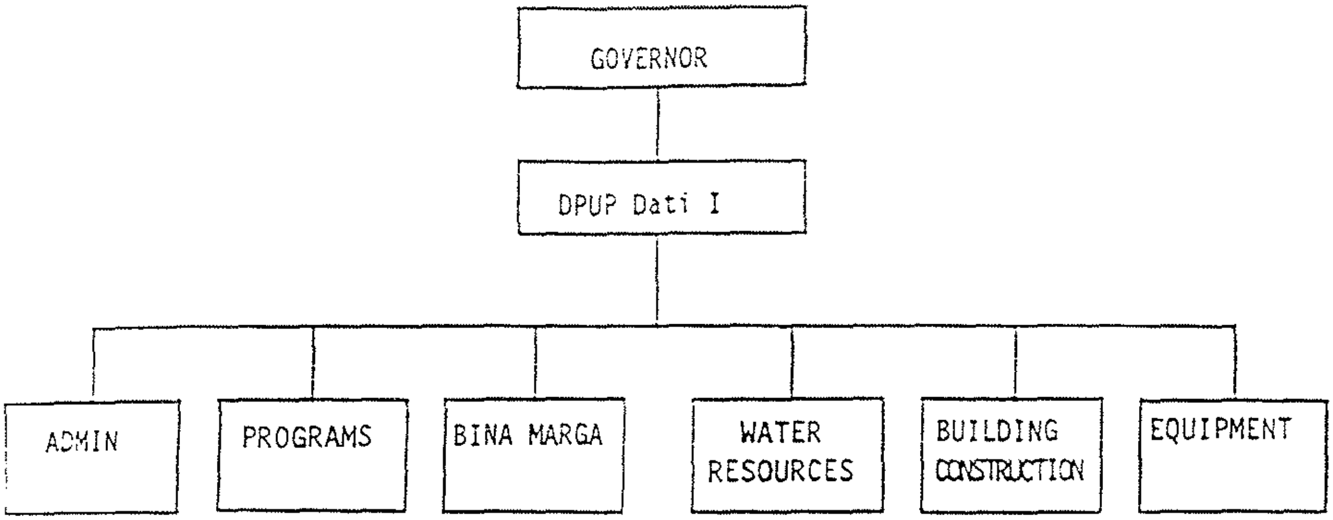
STRUKTUR ORGANISASI BINA MARGA (BANTUAN TEKNIK)

ORGANIZATIONAL STRUCTURE OF THE DIRECTORATE GENERAL OF HIGHWAYS (DGH)



ORGANIZATION CHART FOR PROVINCIAL PUBLIC WORKS DEPARTMENT (DPUP)

STRUKTUR ORGANISASI DPUP (BANTUAN PROVINSI)



ORGANIZATION CHART FOR KANWIL (PROVINCIAL LEVEL)

STRUKTRU ORGANISASI KANWIL (LEVEL PROPINSI)

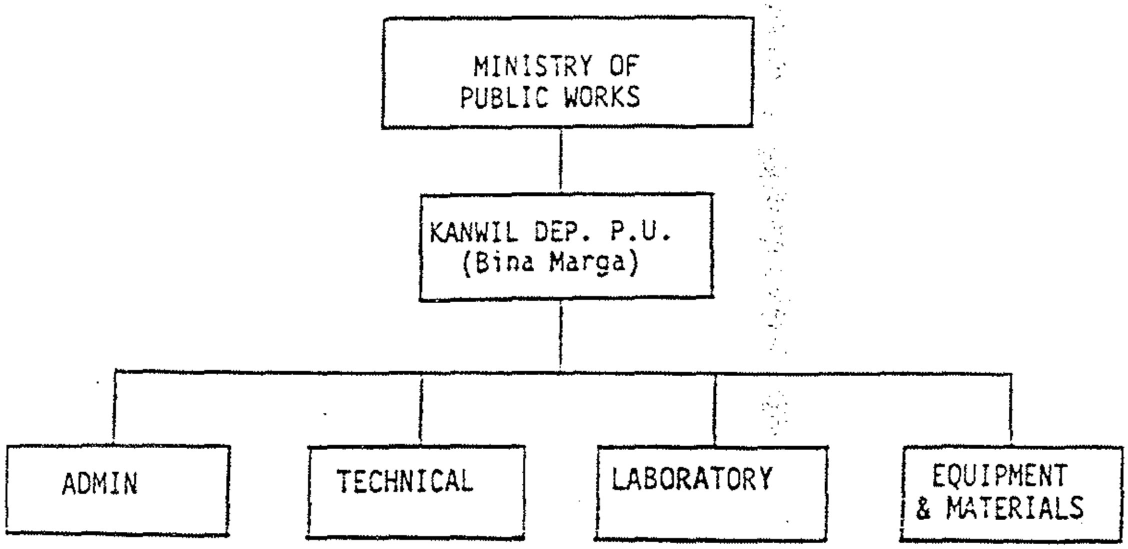
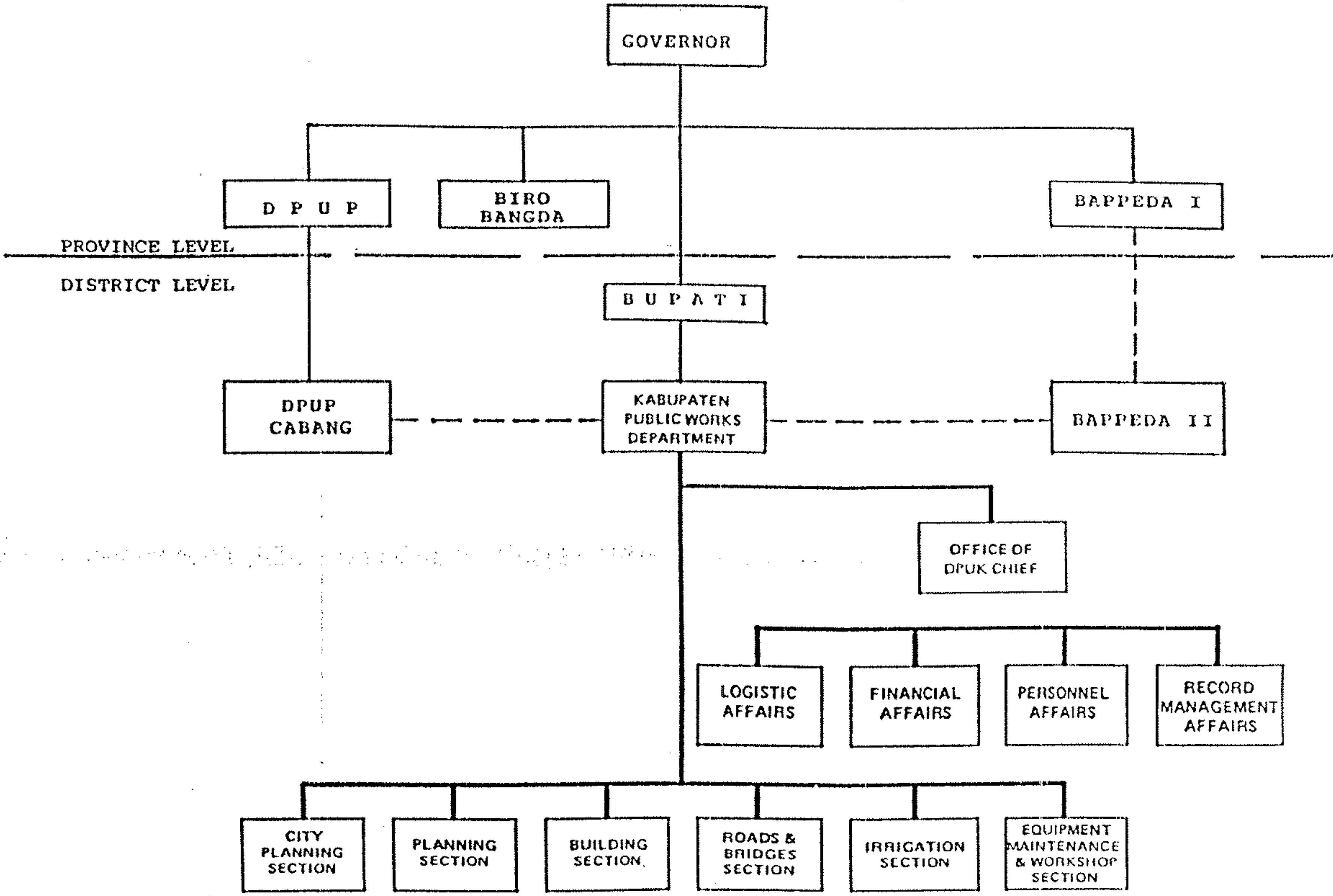


CHART #

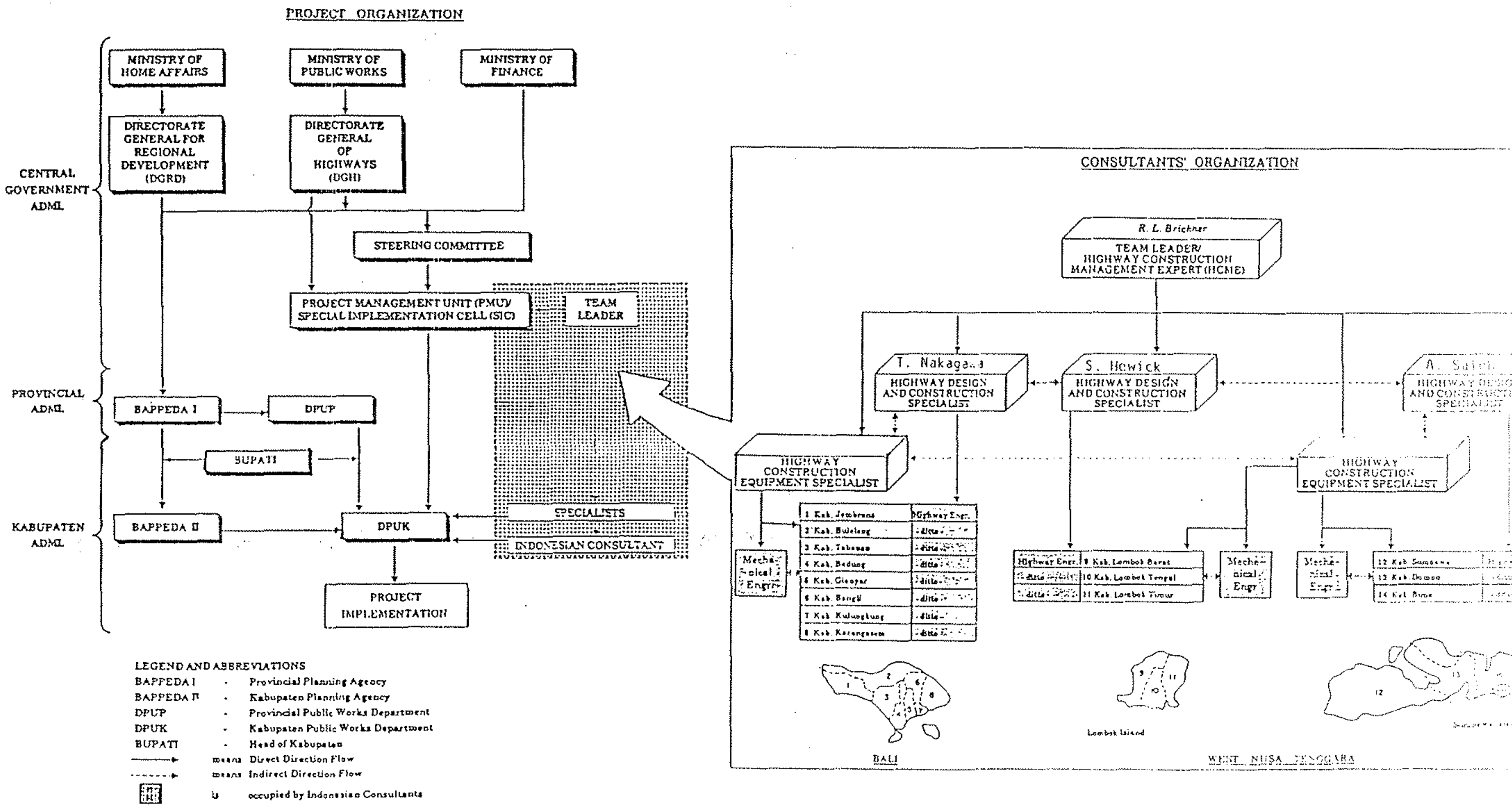
ORGANIZATIONAL STRUCTURE OF KABUPATEN PUBLIC WORKS DEPARTMENT (DPUK)

STRUKTUR ORGANISASI DEPARTEMEN PEKERJAAN UMUM (DPUK)

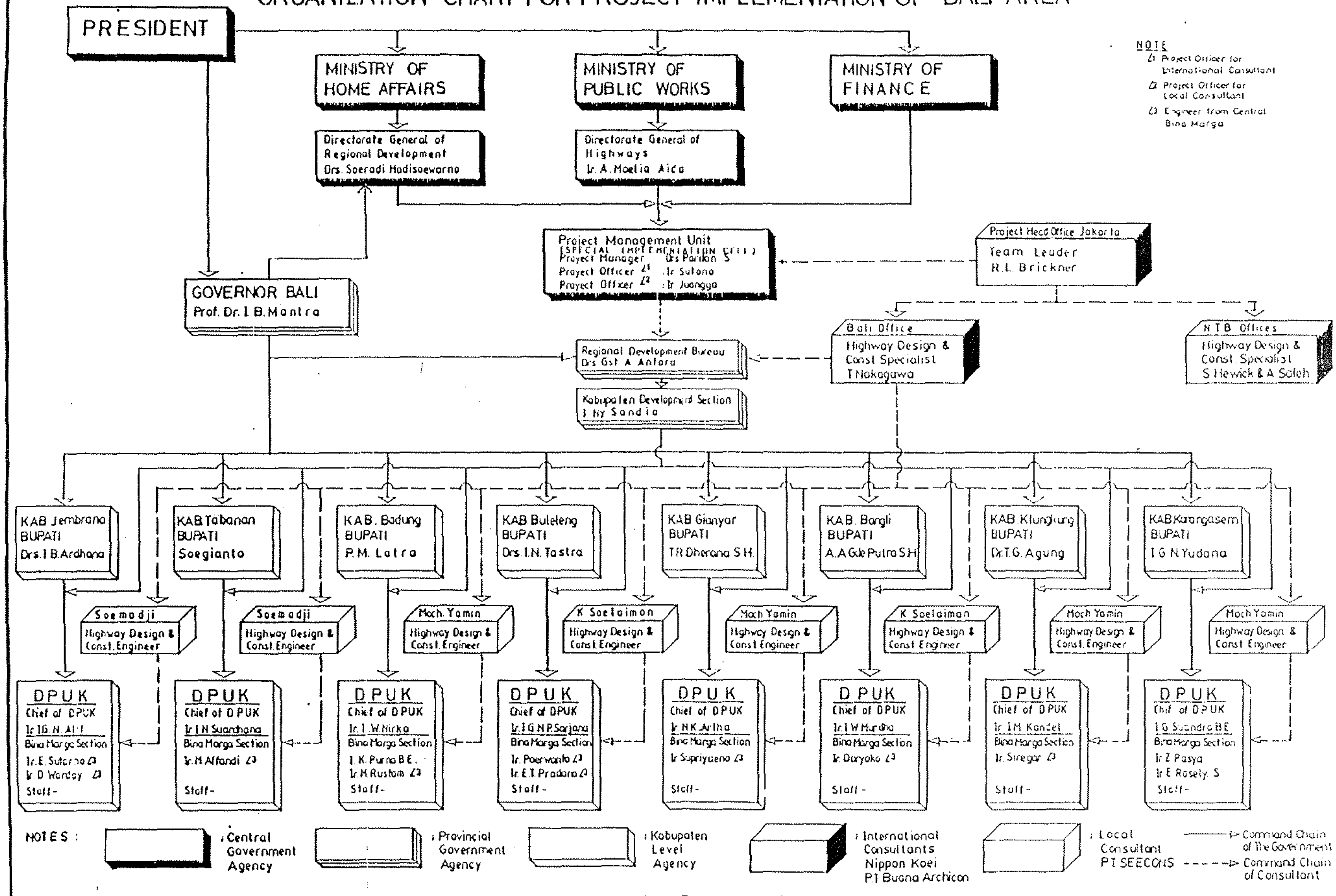


CHART

ORGANIZATION CHART FOR PROJECT IMPLEMENTATION

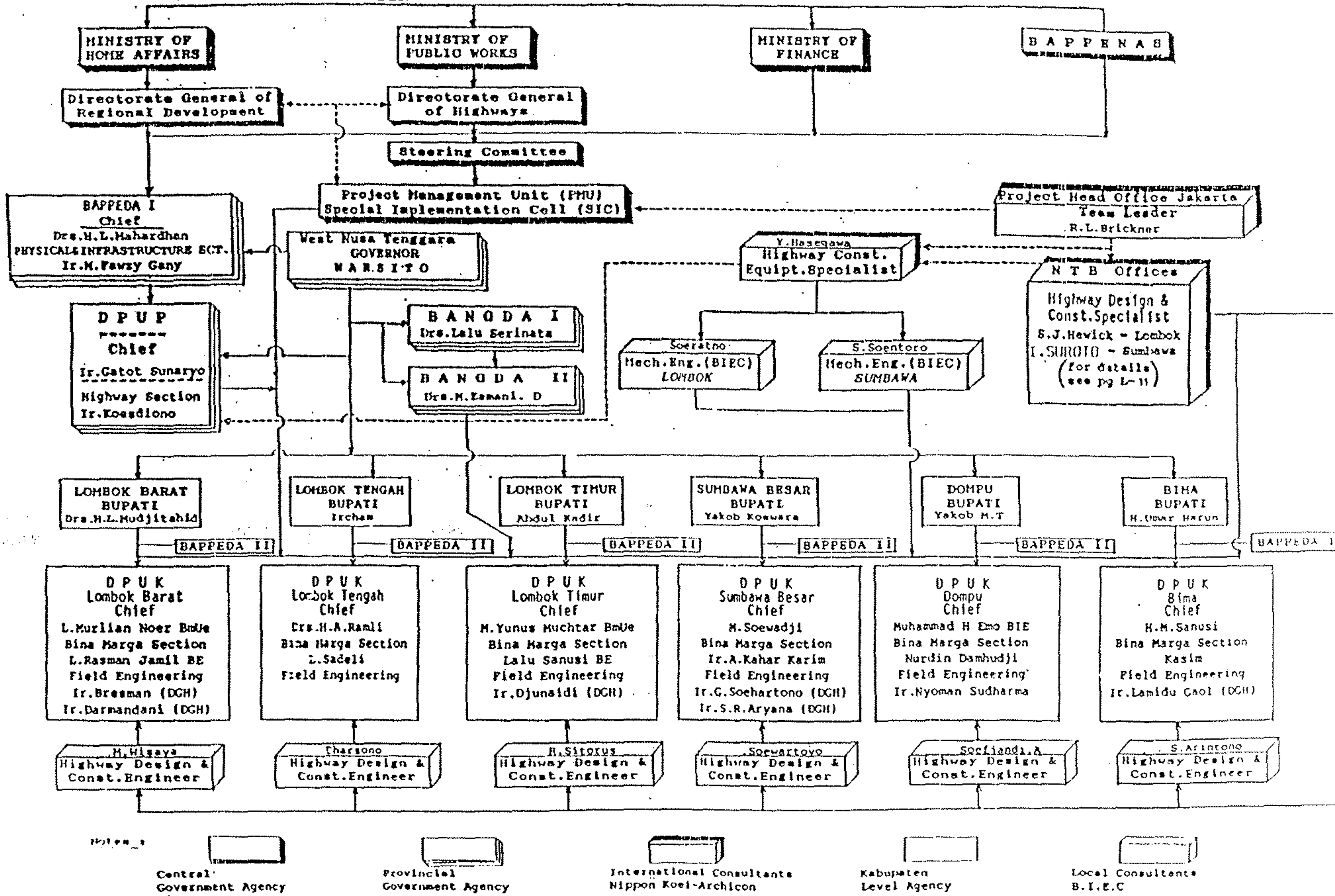


ORGANIZATION CHART FOR PROJECT IMPLEMENTATION OF BALI AREA



ORGANIZATION CHART FOR PROJECT IMPLEMENTATION OF WEST NUSA TENGGARA PROVINCE

STRUKTUR ORGANISASI UNTUK PROYEK IMPLEMENTASI DI NTB



GENERAL NATURE OF CONSULTING SERVICES REQUIRED

CONSULTING ENGINEERING AND SUPERVISORY SERVICES

1. To assist Provincial Public Works Departments (DPUPs) in their monitoring and support of the Kabupaten Public Works Departments (DPUKs) who will implement the Civil Works.

   The Consultant's staff to do this will consist of one Core Team, eight Sub teams, and thirty nine Supervisory Teams.

2. To prepare standards and manuals for design, tendering, and supervision of the works.

3. To assist and support DPUK staff to execute the project in their Kabupatens, and to control the Supervisory Teams.

4. To supervise construction in cooperation with DPUK staff.

5. To implement appropriate computerised project management and data processing methods and procedures relevant to the Project.

6. To conduct required coordination between agencies involved in monitoring the project progress.

Any Civil works from the Local Road Development Project (II) caried over into the 1991/1992 fiscal year are included in the above works.

CONSULTING ADVISORY AND TRAINING SERVICES

1. To prepare text and training materials, in English and Indonesian languages.

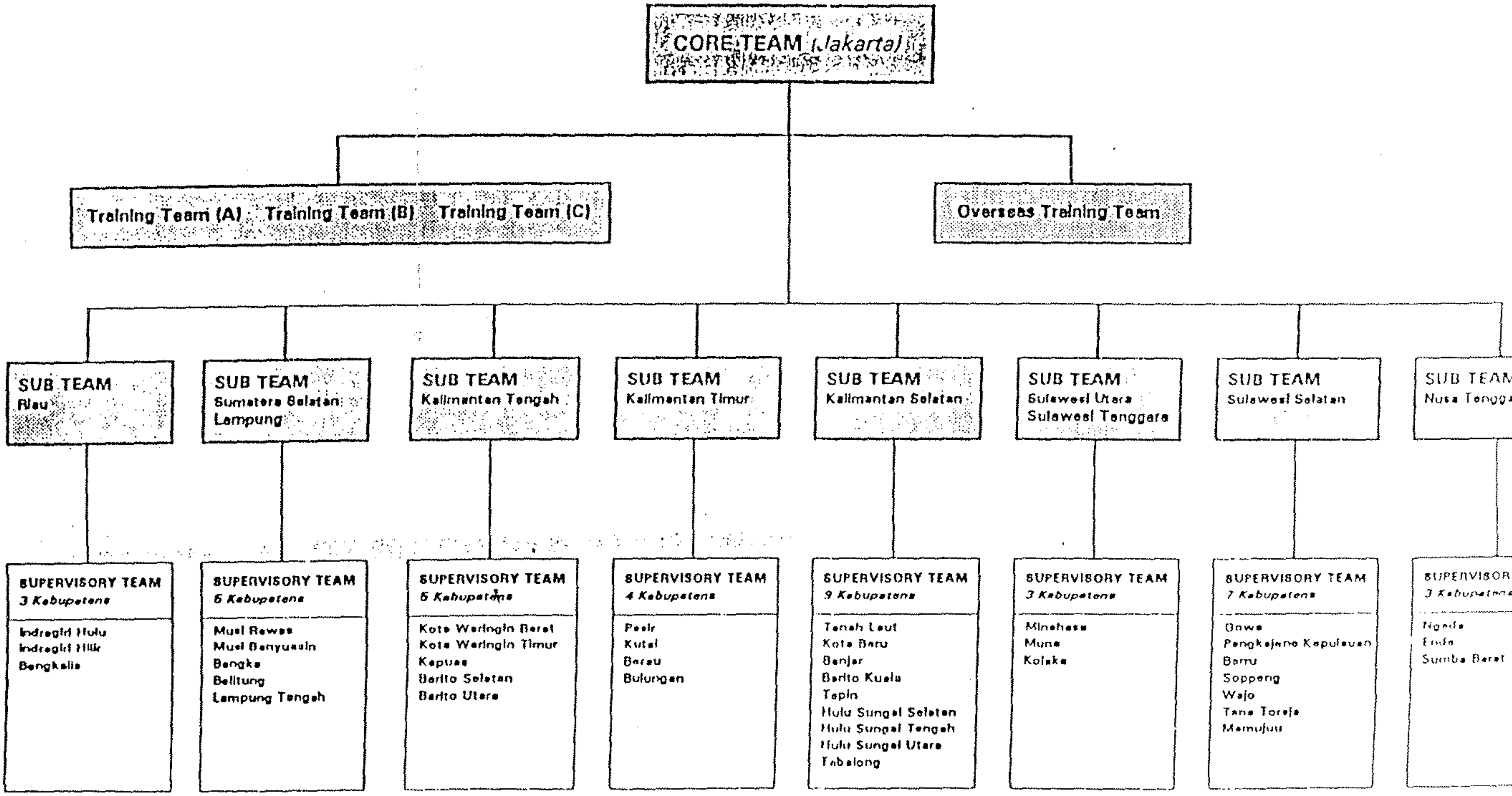
2. To conduct technical advisory services and training servises for DPUK operators and mechanics through the on-job training in cooperation with Bina Marga's Education and Training Project Team (DIKLAT Bina Marga). Three training teams will be involved.

3. To conduct the on-the-job training for Indonesian Associate Consultants and DPUK staff through the routine work of contract administration, project management, design and supervision.

4. To conduct overseas training for fifteen DPUK and Bina Marga technical and management staff in the fields of project management and administration, and local road and contruction maintenance. The training will be for one month, and training will be carried out probably in Yapan or Taiwan.

CHART 7

CONSULTANT'S ORGANISATION



DETAILED SCOPE OF CONSULTING SERVICES REQUIRED

CORE TEAM

1. Review, manage, and coordinate overall project implementation.

2. Provide a computerised program for consultants invoice, work sheet cost analysis.

3. Provide a computerised program for tender document or DURP including bill of quantity etc.

4. Prepare general guidlines, implementation schedule, standard tender document, report formats, technical manual and texts for Kabupaten guidlines and training services, in English and Indonesian languages .

5. Prepare and implement appropriate programme computerised project management and data processing methods covering such areas as :

   - Scheduling
   - Cost Control
   - Road Inventory
   - Reporting
   - Communications

6. Coordinate with concerned agencies to smooth project implementation.

7. Assist in the supplementary procurement of maintenance equipment.

8. Control and assist the Sub Teams and Training Teams.

9. Compile report from the Sub Teams.

10. Report overal project implementation in the Monthly Progres Meeting in Bina Marga.

11. Coordinate with the Sub Directorate of Local Road in the Western, Central and Eastern Regional of Directorate Implementation of DHG, to smooth Project Implementation.

SUB TEAMS

Sub Team are under coordination of DPUP/PBPJK.

1. Review, and coordinate the project at the Provincial level (DPUP/PBPJK, Bangda I and Bappeda I).

2. Prepare schedules and reports after approvel from DPUP/PBPJK.

3. Implement computerised project management and data processing methods appropriate to Province-level tasks.

4. Assist and support DPUP/PBPJK and DPUK staff to carry out all detailed scope of com services.

5. Check and approve finished designs against actual field conditions.

6. Record and report work revisions in a monthly progress report.

7. Assist DPUK to prepare tender documents.

8. Coordinate with concerned Provincial agencies to smooth project implementation (DPUP/PBPJK,Bangda I and Bappeda I).

9. Assist and approve DPUK in contract procurement for both improvement and maintenance works.

10. Control and assist the Supervisory Teams.

11. Assist the Training Teams as required.

12. Supervise and compile reports from the Supervisory Teams.

13. Attend monthly progress meeting in Jakarta.
    Monthly for Sub Team Leader.
    Bemonthly for co-Subteam Leader

SUPERVISORY TEAMS

Supervisory team are under coordination of DPUK

1. Assist DPUK staff and contractors to carry out construction smoothly and properly.
2. Assist and support DPUK staff to carry out detailed design and Tender Document/DURP.
3. Approve detailed design and tender document/DURP.
4. Assist and support DPUK to conduct tests related to quality control procedure.
5. Certify Contractor's Progress based on the result of the laboratories test
6. Certify SP2RK (Monthly Certificate) and advance payment.
7. Recommend and report on problems and progress.
8. Assist DPUK staff in negotiating with contractors on any price on any price or rate change for which the need may arise, and make recommendations on these as may be necessary.
9. Assist the Training Teams as required.
10. Prepare Monthly Progrees Report, Certificates of payment Quartely Report, and other necessary reports as instructed by the Sub Teams.
11. Attend monthly progress meetings in the provincial office.
12. Conduct on the job training for DPUK laboratories covering the use and maintenance laboratories equipment.

Project implementation schedule is shown in figure 5.1. The estimated total man-months for this consultancy services is 4,410 M/M (Expatriate 204 M/M Local 4,206 M/M) The required assigments are as follow :

CORE TEAM (1 Number)

Team Leader	- (Expatriate)
Co-Team Leader	- (Indonesian)
Systems Analyst	- (Expatriate)
Highway Engineer	- (Expatriate)
Documentation Specialist	- (Expatriate)
Training Coord.	- (Expatriate)
Assistant Systems Analyst	- (Indonesian)
Senior Quantity Technician	- (Indonesian)
Office Support Staff	- (Indonesian)

SUB-TEAM (8 Number)

Sub-Team Leader	- (Expatriate)
Co-Sub Team Leader	- (Indonesian)
Highway Engineer	- (Indonesian)
Assistant Systems Analyst	- (Indonesian)
Senior Quantity Technician	- (Indonesian)
Office Support Staff	- (Indonesian)

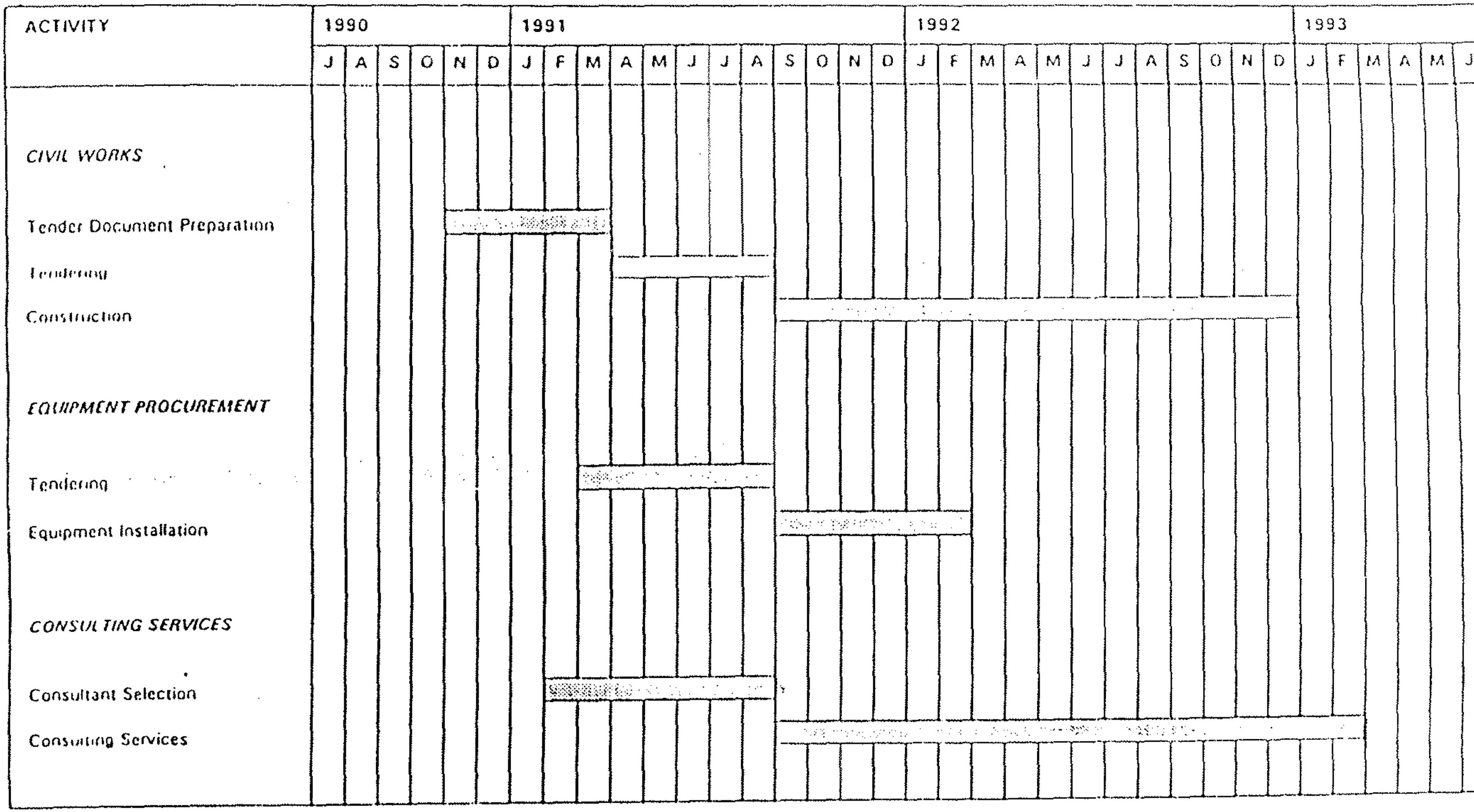
SUPERVISION TEAMS (39 Number)

Civil Engineer	- (Indonesian)
Senior Quantity Technician (A)	- (Indonesian)
Senior Quantity Technician (B)	- (Indonesian)
Office Support Staff	- (Indonesian)

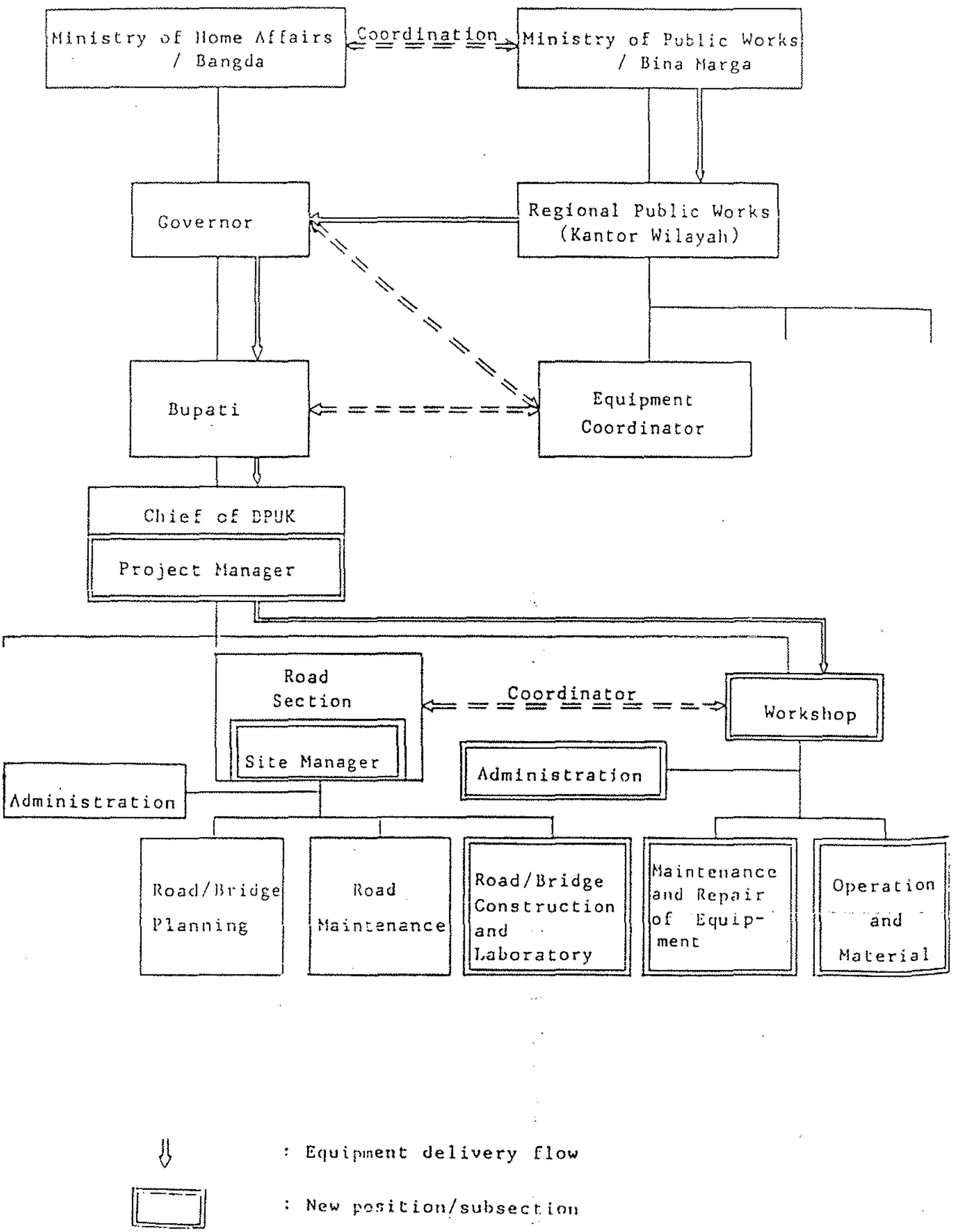
TRAINING TEAMS (3 Number)

Mechanical Engineer	- (Expatriate)
Mechanical Engineer	- (Indonesian)
Mechanical Trainer	- (Indonesian)

PROJECT IMPLEMENTATION SCHEDULE



PROPOSED ORGANIZATION



LABORATORY TEST EQUIPMENT

DESCRIPTION	QUANTITY
Soil Moisture Test Set (JIS A1203)	1
Liquid Limit Set (JIS A1205)	1
Plastic Limit Set (JIS A1206)	1
Compaction Set (JIS A1210)	1
CBR Laboratory Set, Mechanical (JIS A1211)	1
Sand Density Apparatus (JIS A1214)	1
Aggregate Test Sieve Set	1
Portable Cone Penetrometer	1
Compression & Bending Test Machine	1
Cylinder Mould (JIS A1132, 1108)	9
Slump Test Apparatus (JIS A1101)	2

To conduct the surveys necessary for road and structure construction such as centering, profile leveling, cross section leveling etc., the surveying equipment listed in Table 3-5-3 recommended.

SURVEYING EQUIPMENT

DESCRIPTION	QUANTITY
Transit	1
Level	1
Staff	3

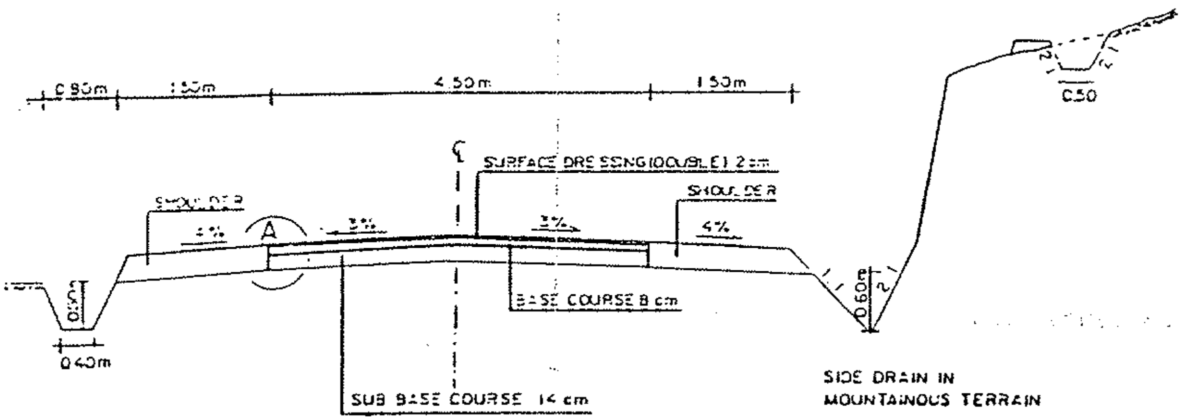
DESIGN CRITERIA FOR KABUPATEN ROADS

ROAD CLASSIFICATION		CLASS III A			CLASS III B-1			CLASS III B-2			CLASS III C		
SURFACE TYPE		ASPHALT SEAL (DOUBLE)			ASPHALT SEAL (SINGLE)			GRAVEL			GRAVEL		
TRAFFIC VOLUME : ADT (Forecast 10 th year average per day)		3000 - 500			500 - 200			200 - 50			50		
TERRAIN		FLAT TO ROLLING	HILLY	MOUNT-AINOUS	FLAT TO ROLLING	HILLY	MOUNT-AINOUS	FLAT TO ROLLING	HILLY	MOUNT-AINOUS	FLAT TO ROLLING	HILLY	MOU AIN
TRAFFIC LANES		1+	1+	1+	1+	1+	1+	1+	1+	1+	1	1	
DESIGN SPEED (Km/hr)	DESIRABLE	70	60	40	70	40	30	60	40	30	50	30	AS P CA
	MINIMUM	30	30	30	30	30	AS PRACTICABLE	30	30	AS PRACTICABLE	30	AS PRACTICABL	
GRADIENT (LIMITING) (%)	DESIRABLE	4	5	8	4	6	8	4	7	8	5	8	
	MAXIMUM	7	7	10	7	8	10	7	9	12	7	12	
PAVEMENT WIDTH (M)	DESIRABLE	6.0	6.0	6.0	4.5	4.5	4.5	4.5	4.5	4.5	3.5	3.5	3
	MINIMUM	4.5	4.5	4.5	3.5	3.5	3.5	3.5	3.5	3.5	3.0	3.0	3
SHOULDER WIDTH (M)	DESIRABLE	2.0	1.5	1.5	1.5	1.5	1.0	1.5	1.0	1.0	1.0	1.0	0
	MINIMUM	1.5	1.0	0.75	1.0	1.0	0.75	1.0	0.75	0.5	0.75	0.5	0
ROAD BED WIDTH (M)	DESIRABLE	10.0	9.0	9.0	8.0	7.5	6.5	7.5	6.5	6.5	5.5	5.5	5
	MINIMUM	6.0	6.0	6.0	5.5	5.5	5.0	5.5	5.0	4.5	4.5	4.0	4
RIGHT OF WAY (M)	DESIRABLE	16			12			12			12		
	MINIMUM	12			10			10			8		
ROAD CAMBER (%)	PAVEMENT	3			3			4			4		
	SHOULDER	4			4			5			5		

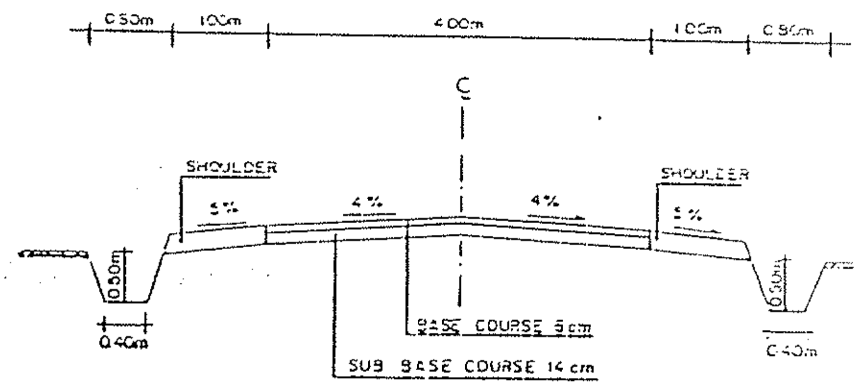
CHART A

STANDARD ROAD CROSS SECTIONS

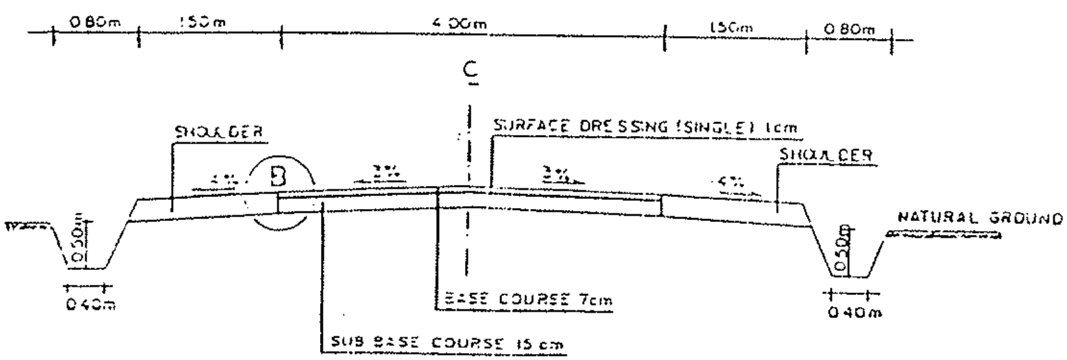
CLASS III A



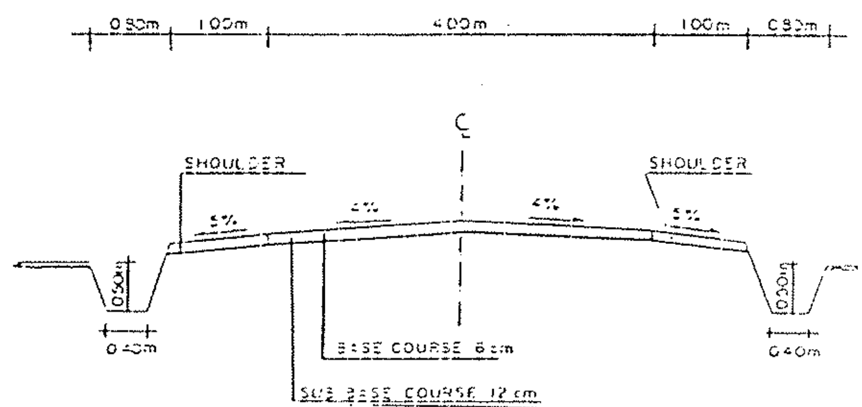
CLASS III B-2



CLASS III B-1

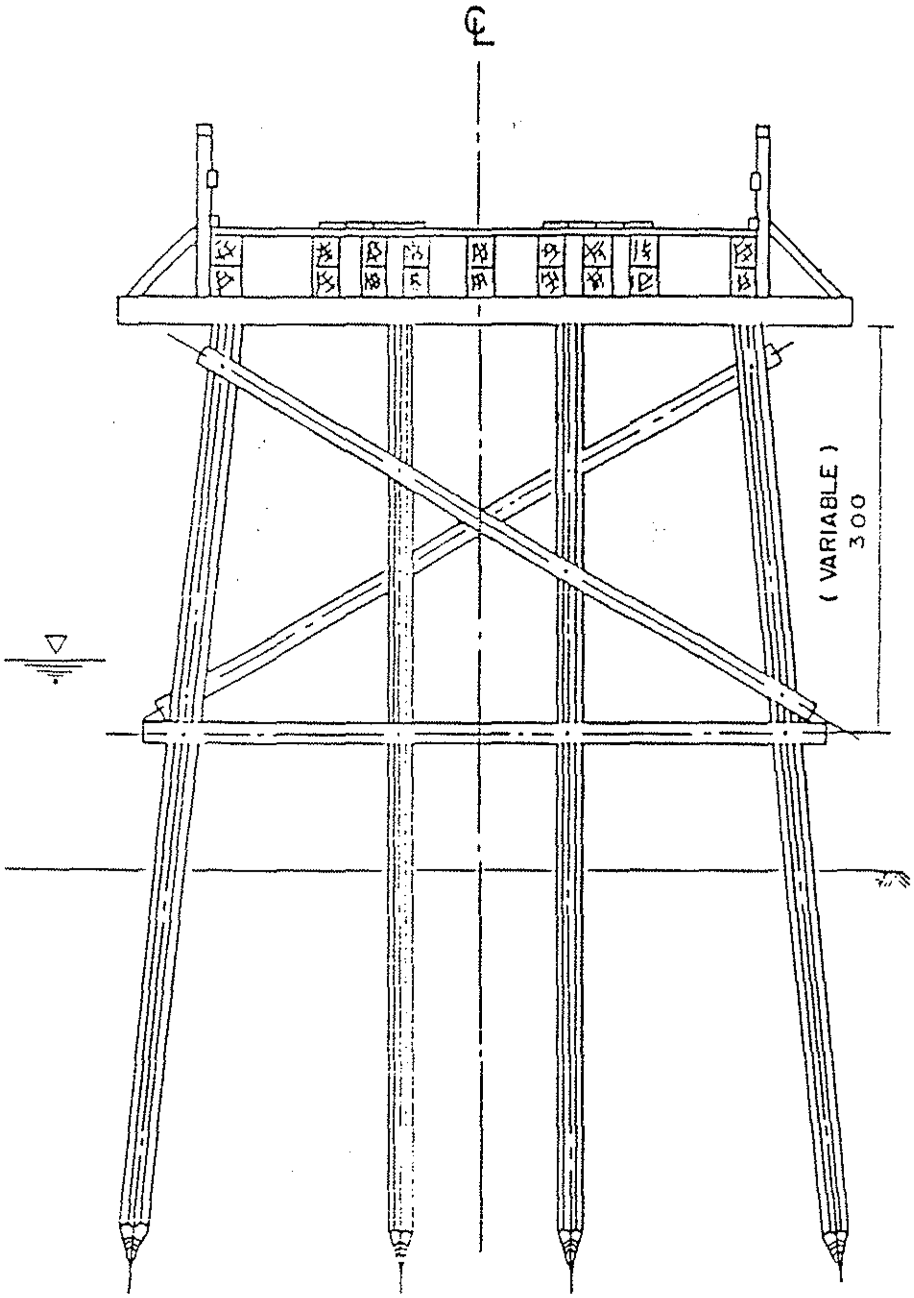


CLASS III C



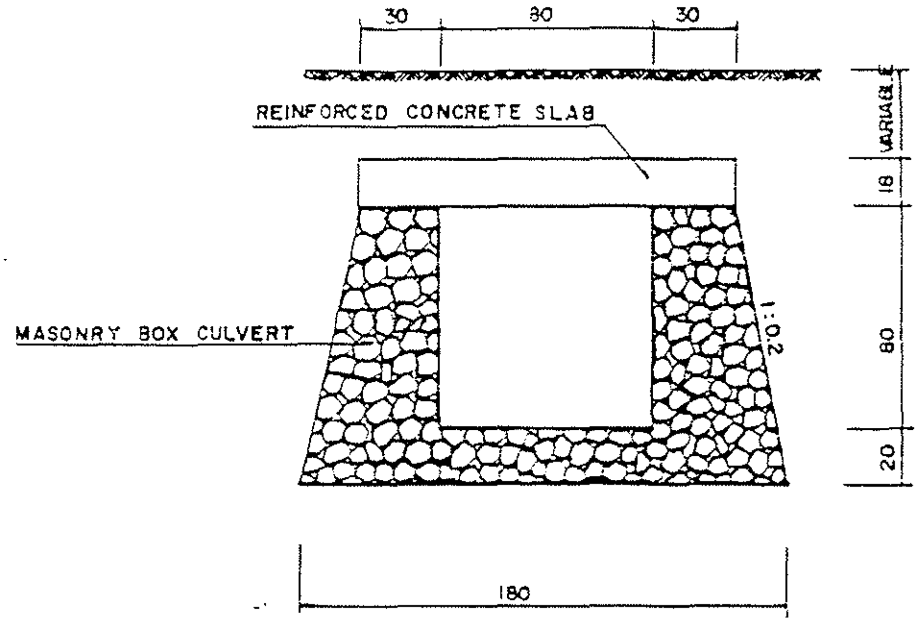
CROSS SECTION OF STANDARD BRIDGE

TIMBER BRIDGE

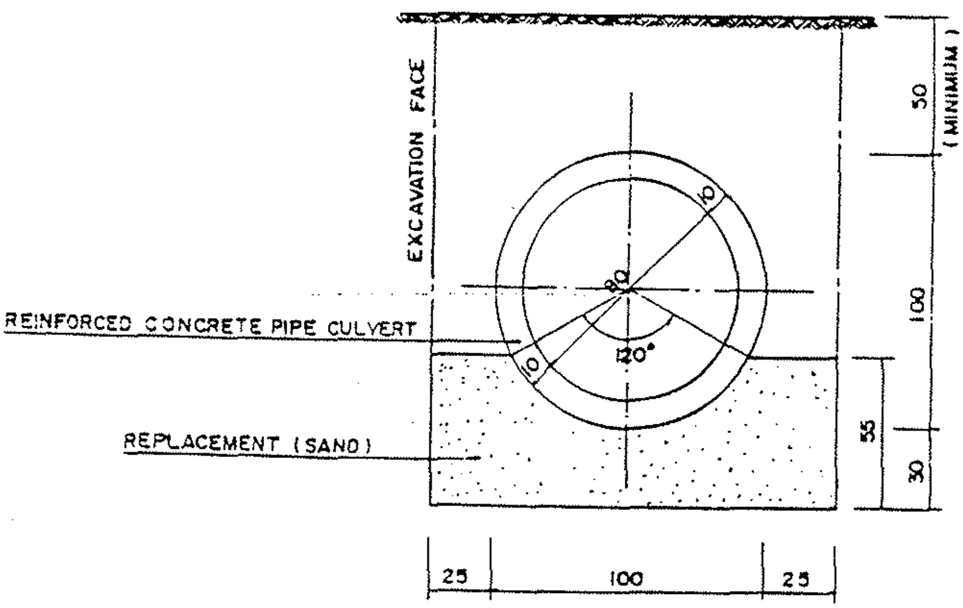


STANDARD CULVERTS

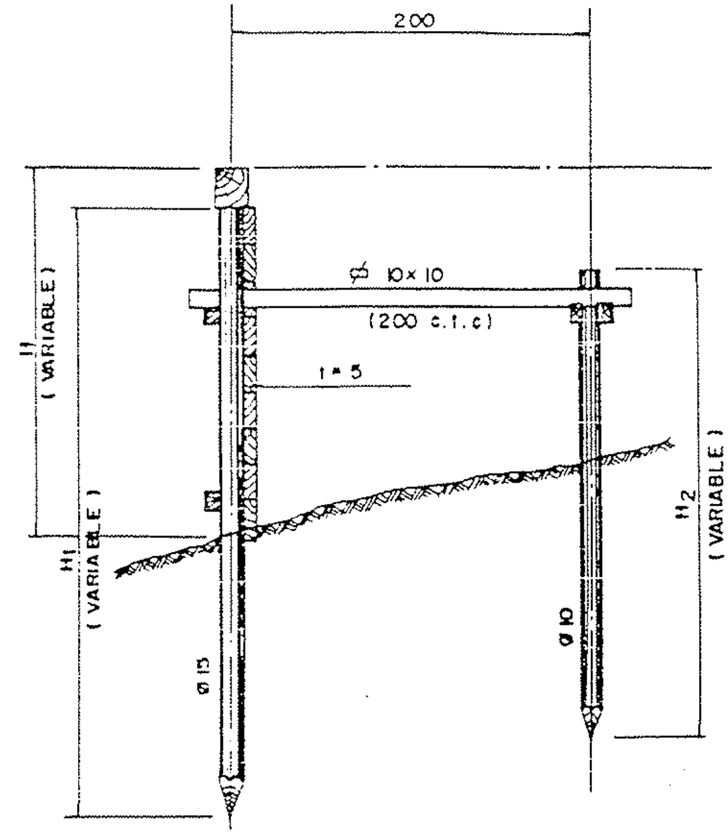
80 x 80 RUBBLE IN MORTAR BOX CULVERTS



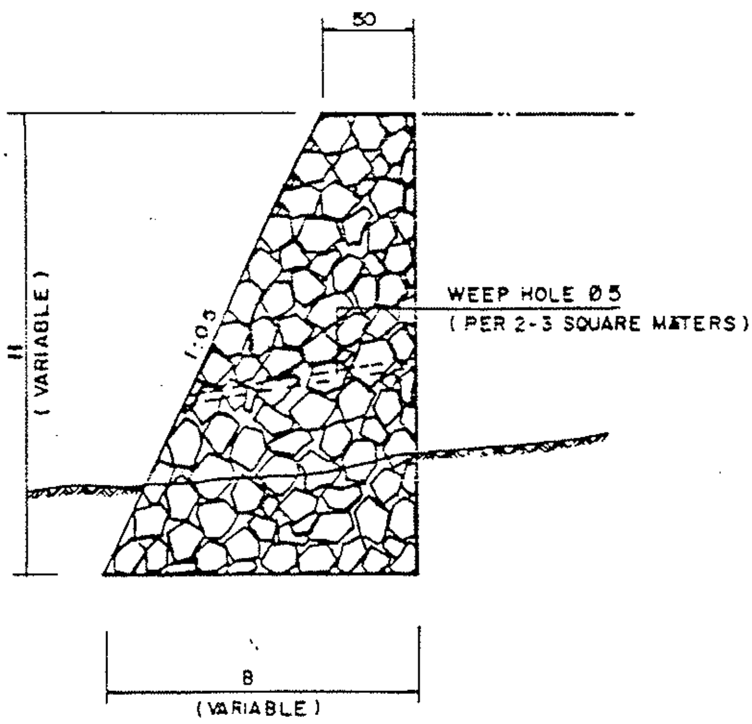
Ø 80 RENFORCED CONCRETE PIPE CULVERT



TIMBER RETAINING WALL



RUBBLE IN MORTAR WALL



EQUIPMENT OF ONE WORK GANG FOR MAJOR
TYPES OF WORK

TYPE OF WORK	EQUIPMENT REQUIRED	
1. Site Clearing in Light Bush	1- Bulldozer 90 HP 2- Dump Truck 3.0 Ton	1- Wheel Loader 1.2 m^3
2. Excavation & Embankment		
i) Normal Fill	1- Bulldozer 90 HP 1- Vibratory Roller 4.0 Ton (D&T)	1- Water Tank Truck 4,000 Ltr
ii) Fill by Borrow Material	1- Bulldozer 90 HP 3- Dump Truck 3.0 Ton	1- Wheel Loader 1.2 m^3
iii) Fill in Swamp	1- Swamp Bulldozer 90 HP 1- Water Tank Truck 4,000 Ltr	1- Vibratory Roller 4.0 Ton (D&T)
iv) Excavation to Spoil	1- Bulldozer 90 HP 1- Wheel Loader 1.2 m^3	4- Dump Truck 3.0 Ton
3. Subgrade Preparation	1- Motor Grader 75 HP 1- Vibratory Roller 4.0 Ton (D&T)	1- Water Tank Truck 4,000 Ltr
4. Subbase Course	1- Motor Grader 75 HP 1- Vibratory Roller 4.0 Ton (D&T)	1- Water Tank Truck 4,000 Ltr
5. Base Course	1- Motor Grader 75 HP 1- Vibratory Roller 4.0 Ton 1- Portable Crusher/Screens 30-40 Ton/H	1- Water Tank Truck 4,000 Ltr
6. Cement Stabilizing	1- Motor Grader 70 HP 1- Bulldozer 90 HP 1- Wheel Loader 1.2 m^3 1- Flat Bed Truck 3.0 Ton	1- Vibratory Roller 4.0 Ton (D&T) 1- Road Stabilizer 1- Water Tank Truck 4,000 Ltr
7. Surface Course	1- Asphalt Sprayer 850 Ltr 1- Tyre Roller 8-15 Ton 1- Portable Crusher/Screens 30-40 Ton/H	1- Flat Bed Truck 3.0 Ton
8. Concrete	1- Concrete Mixer 0.5 m^3 1- Water Pump 200 Ltr/Min 1- Concrete Vibrator 3.3 HP	1- Flat Bed Truck 3.0 Ton 1- Hand-Guided Vibratory Roller 1000 Kg

CONSTRUCTION MATERIALS FOR RURAL ROADS

LOCATION	MATERIAL	DESCRIPTION
SUB BASE	Sub-base course material For use when CBR < 25%	Mixture of graded stone or gravel, with sand and limited clay content
BASE COURSE	Water bound Macadam	Single size stone (37.5-50 mm) blinded and watered.
	Crushed graded stone (Also includes AMCAS)	37.5-50 mm down to specification, compacted in 100-150 mm layers.
	Lime Stabilised Soil	3%-5% slaked lime mixed in-situ (to give 18 Kg/cm^2)
PAVEMENT SURFACE	Penetration Macadam	Traditional method and labour intensive. Suitable to improved specification and quality control.
	Bitumen Surface Treatment	Surface Dressing Treatment (single or double)
	Asbuton Overlay	Natural treated Asphalt mixed with graded mineral aggregate (35:65) laid hot or cold min 4 cm layer.

FUNDING OF LOCAL ROADS
BIAYA JALAN LOKAL (PEMBAYARAN)

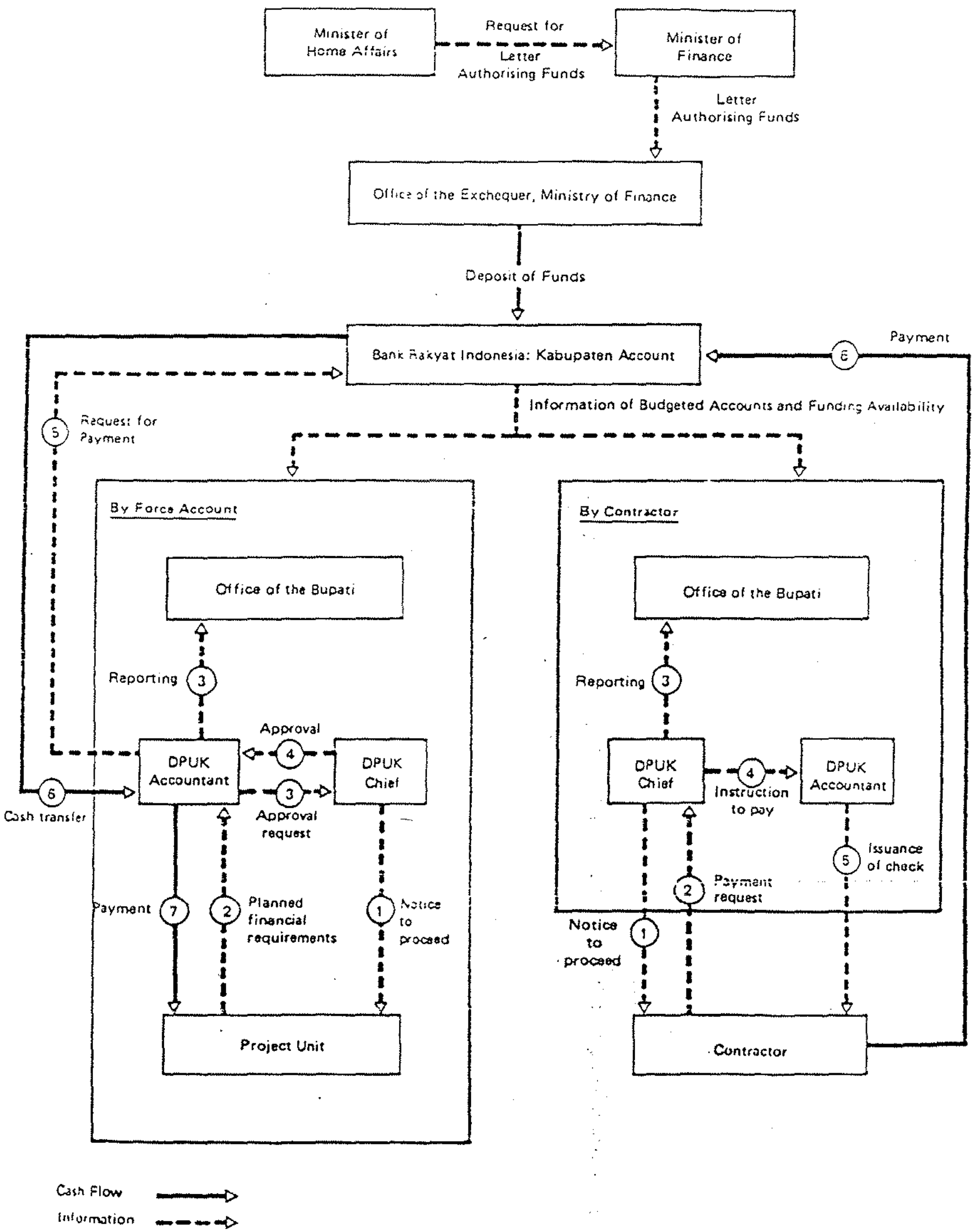
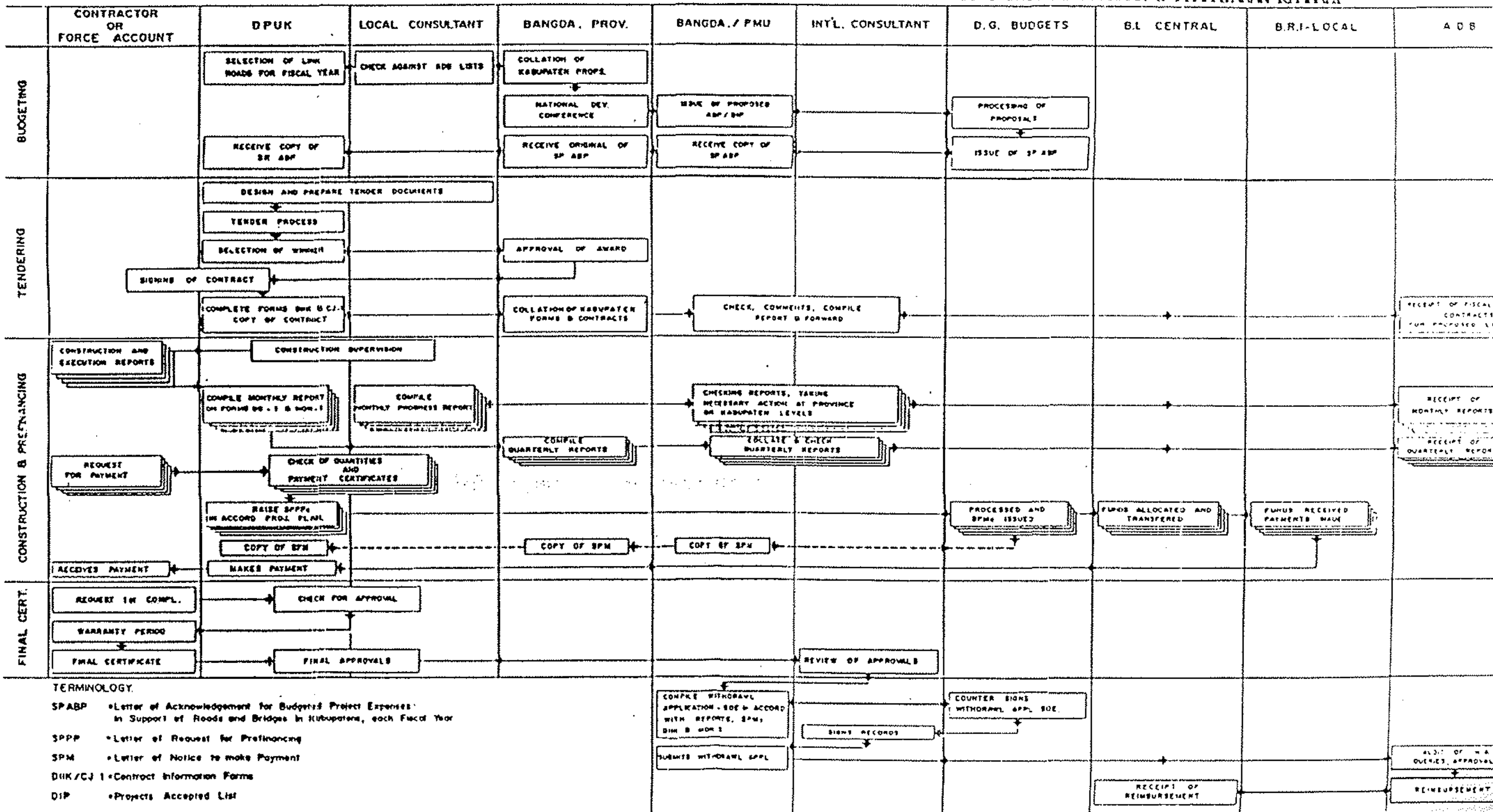


CHART #

LOCAL DEVELOPMENT PROJECT
RURAL ROADS II-ADB EIGHTH ROAD
PROCESS FOR PREFINANCING & REIMBURSEMENT PROSES UNTUK PENDANAAN & PEMBAYARAN KEMBALI



TERMINOLOGY.

SPABP = Letter of Acknowledgement for Budgeted Project Expenses In Support of Roads and Bridges in Kabupatens, each Fiscal Year

SPPP = Letter of Request for Prefinancing

SPM = Letter of Notice to make Payment

DIIK/CJ 1 = Contract Information Forms

DIP = Projects Accepted List

Road Maintenance

Provision is made for road maintenance and periodic support works in the kabupaten programmes. Manuals are provided for the guidance of the Kabupaten staff, detaling management procedures, plant and equipment requirements, field work units, and maintenance levels of service, to follow for the four road classifications.

Work categories are defined within the following limits:

LIST OF ROAD MAINTENANCE WORKS

LOCATION	MAINTENANCE WORKS	
	ROUTINE MAINTENANCE	PERIODIC SUPPORT WORKS
ROAD	- Patching/Pothole repair - Grading and reshaping - Shoulder repair (minor) - Vegetation control - Erosion control - Traffic Signs and sundries	- Surface reseal (SST) - Major patching and repair - Renewal of gravel overlay - Rebuilding shoulders - Removal of bank slips and other emergency works - Flood damage repair
DRAINAGE	- Culvert cleaning/repair - Roadside drainage, cleaning and repair	- Major repair to culverts including replacing & extension - Major repair and regrading side drains.
BRIDGE	- Bridge channel and drainage outlet cleaning - Maintenance of bridge deck	- Structural repair (minor work) - Renewal of timber decks - Repairs to handrails/walls - Repainting steel work - Channel, bank and scour protection

Costing and Estimates

Costing procedures. For the preparation of the road and bridge estimates, the kabupaten engineer is required to build up a costing system and establish unit rates for all work activities.

DINDING GESER KAYU
PADA
BANGUNAN BERTINGKAT TAHAN GEMPA

by
Johannes Adhijoso Tjondro

JOINT UNPAR - ASCE SEMINAR
ON
THE STATE OF THE ART OF
CIVIL ENGINEERING PRACTICE
IN INDONESIA

Bandung, 18 May 1991
Parahyangan Catholic University

DINDING GESER KAYU
PADA
BANGUNAN BERTINGKAT TAHAN GEMPA

Johannes Adhijoso Tjondro*

Dari potensi hutan alam yang ada di Indonesia terutama produksi kayu lapisnya harus didukung dengan berkembangnya riset dalam struktur bangunan kayu, terutama pada bangunan bertingkat. Bangunan bertingkat dengan dinding geser kayu merupakan sebuah alternatif baru dalam pemilihan macam struktur bangunan bertingkat tahan gempa di Indonesia. Perilaku dari dinding geser tunggal dan pengembangannya untuk bangunan bertingkat dari hasil riset yang telah dilakukan memberikan konsep dasar untuk pengembangannya di Indonesia.

1. Pendahuluan

Lahan yang makin sempit dan mahal menyebabkan bangunan bertingkat menjadi suatu pilihan selain material yang digunakan pada saat ini yang masih berkisar pada baja dan kayu. Perkembangan yang lambat dan sedikitnya minat pada pilihan material kayu menyebabkan penggunaannya hanya pada bangunan bertingkat rendah dan sebagai non-struktural elemen saja.

Sumber daya alam, potensi hutan yang ada di Indonesia merupakan suatu potensi yang terpendam untuk industri komponen-komponen bangunan kayu, diantaranya plywood dan sejenisnya. Kayu adalah bahan yang ringan, sehingga massa bangunan kayu pada umumnya lebih ringan dari bangunan baja atau beton, dari segi desain terhadap beban gempa hal ini cenderung menguntungkan karena menghasilkan gaya geser dasar yang cukup kecil. Bahan kayu mudah dalam pengangkutan dan pemasangannya di lapangan, dari segi waktu pelaksanaan termasuk cepat bila dibandingkan dengan material yang lain.

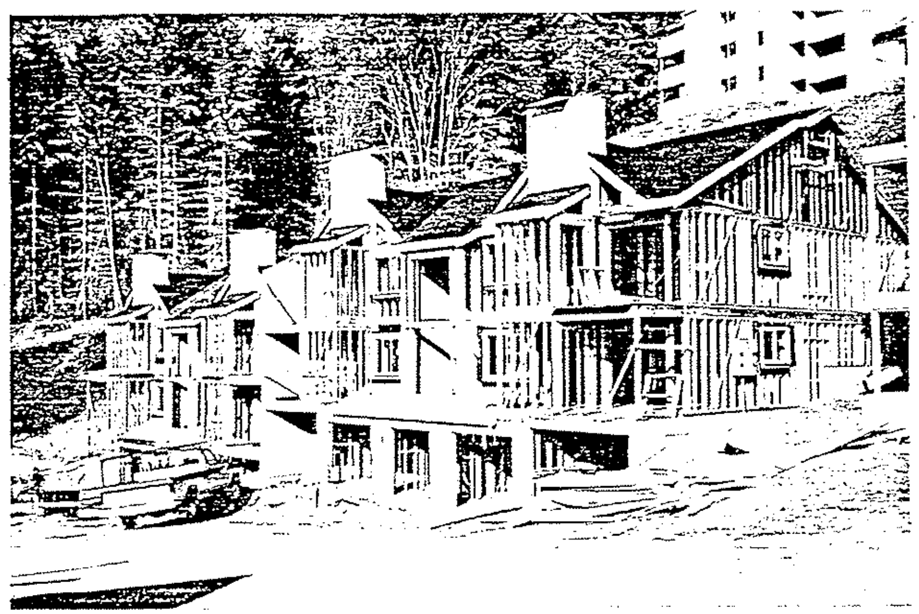
* Staf Pengajar Tetap Fakultas Teknik Jurusan Sipil UNPAR

Sayangnya material kayu belum membudaya, terutama pemakaiannya untuk bangunan-bangunan berbentang besar atau bertingkat di Indonesia, harga pelaksanaannya cukup mahal karena komponen-komponennya sebagian besar masih dikerjakan dengan tenaga manusia dan sistim strukturnya tidak efisien, masih menggunakan sambungan-sambungan konvensionil yang mahal biayanya.

Di Indonesia bangunan bertingkat dari kayu hampir tidak pernah dijumpai, selain untuk bangunan dua lantai. Untuk bangunan bertingkat yang lebih tinggi lagi, beban lateral menentukan dalam desain elemen struktur utamanya, yang pada umumnya strukturnya adalah rangka. Elemen-elemen berupa dinding yang biasanya terbuat dari plywood hanya sebagai dinding penutup saja, padahal sebenarnya mempunyai kekakuan dalam arah lateral untuk menahan beban-beban lateral angin atau gempa. Perkembangan yang terakhir di dunia menunjukkan bahwa panel-panel yang terbuat dari plywood atau sejenisnya tersebut sangat efektif dalam menahan beban lateral. Kemudian dikembangkan pula pada bangunan-bangunan bertingkat dengan dinding geser dari plywood atau sejenisnya.

Sebagai contoh pada gambar 1 dan 2, menunjukkan dua buah bangunan bertingkat yang seluruhnya terbuat dari kayu dengan kombinasi dinding geser kayu di Seattle dan Alaska.

Multi-storey timber buildings – An update

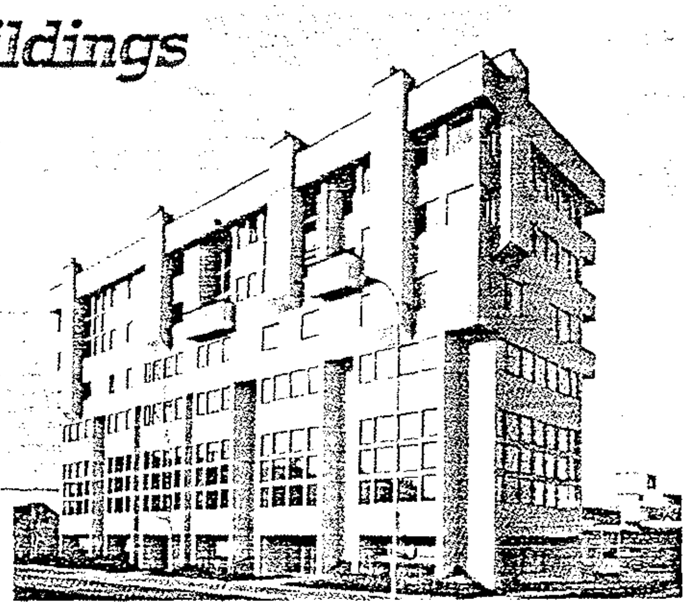


Part of a huge development of three and four storey apartments in Seattle, under construction.

gambar 1

Multi-storey timber buildings

gambar 2

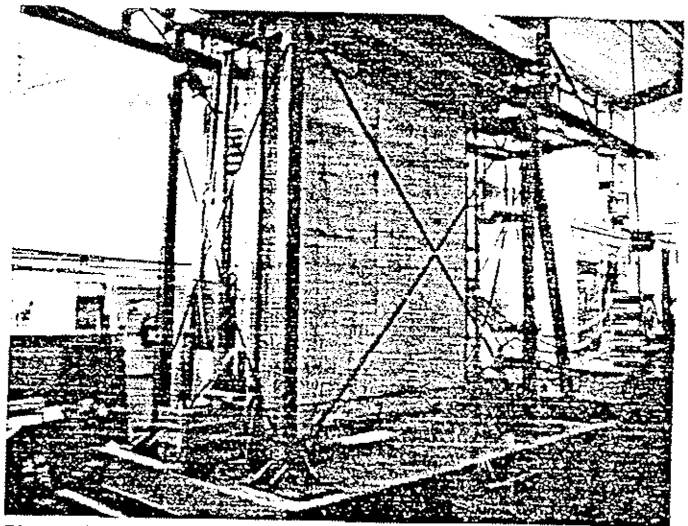


Seven storey office-residential building in Alaska, featured in the March 1987 issue of this Journal.

2. Perilaku dinding geser tunggal

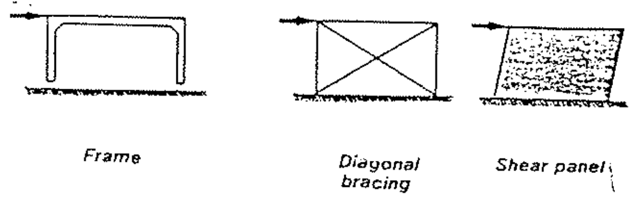
Dinding geser ini mula-mula dikembangkan untuk bangunan satu lantai diantaranya oleh Thurston dan Stewart. Test banyak dilakukan untuk dinding dari plywood yang dikombinasikan dengan rangka dari kayu (Gambar 3). Gambar 4, rangka yang lemah terhadap gaya lateral yang pada umumnya diperkuat dengan bracing mendapat tambahan kekakuan lateral dari panel plywood yang memberikan kontribusi yang besar, sifat dari beban gempa atau angin yang bolak-balik (reversed loading) menyebabkan konsep daktilitas sangat berguna jika dikembangkan untuk beban-beban tersebut. Sesuai dengan konsep equal displacement atau equal energy, level beban untuk desain elastis diturunkan pada tingkat daktilitas tertentu.

Daktilitas dari dinding geser kayu ini diperoleh dengan kemampuannya untuk mengalami simpangan inelastis, yang dicapai dengan kelelehan alat penyambungnya yang berupa paku dengan memberikan batasan tidak terjadinya 'brittle failure'.



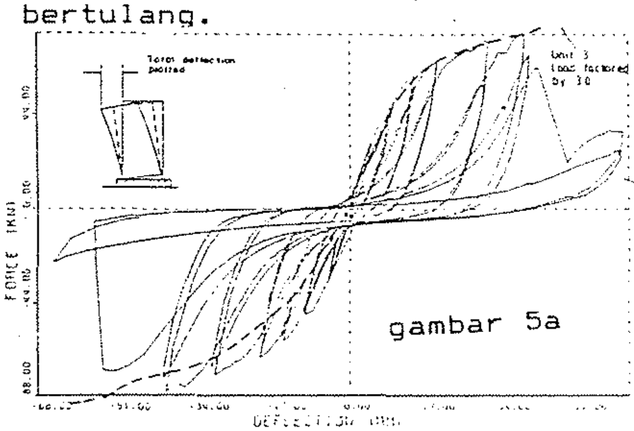
Plywood shear wall being tested under simulated earthquake loading on the shaking table.

gambar 3

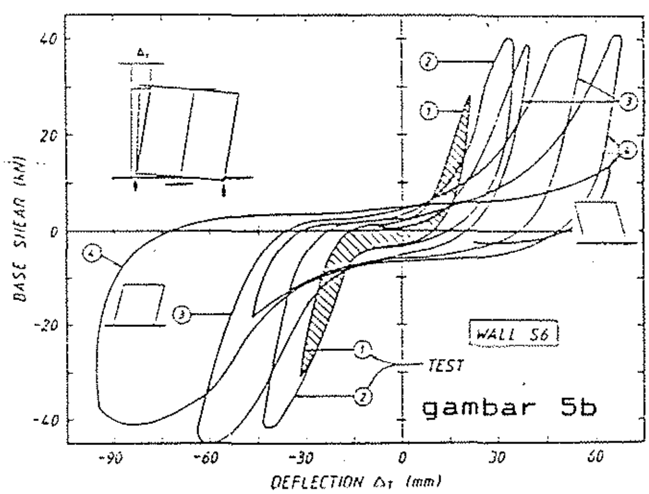


gambar 4

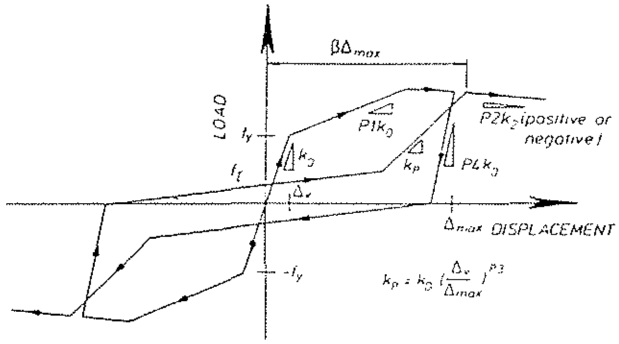
Hysteresis curve yang terjadi pada dinding geser kayu ini tidak seperti pada baja atau beton bertulang, karena disini terjadi slip pada pakunya, dari hasil percobaan terlihat seperti pada gambar 5a dan 5b, menunjukan hubungan antara gaya geser dasar dan peralihan horisontal akibat beban berulang. Hysteresis curve ini berbeda karakteristiknya tidak seperti anggapan elasto-plastis atau bi-linier pada baja ataupun Ramberg-Osgood model pada beton bertulang.



Cyclic Load Test on Plywood Sheathed Wall (from Thurston, 1984).



Stewart mengembangkan hysteresis curve untuk dinding geser kayu ini dan subroutine dari Stewart Hysteresis model (gambar 6) terdapat dalam program Ruaumoko di Department of Civil Engineering, University of Canterbury.



gambar 6

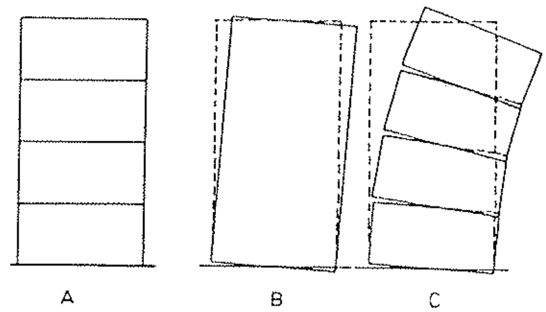
Parameter-parameter yang mempengaruhi bentuk hysteresis tersebut tentu saja tergantung dari karakteristik bahan plywood, jarak pemakuan, tebal lapisan dan jumlah plywood pada satu atau dua sisi dari rangkanya. Parameter-parameter tadi harus dicari dari hasil percobaan di laboratorium.

3. Dinding geser kayu pada bangunan bertingkat

Dari hasil percobaan dan dengan analisis berdasarkan Stewart hysteresis model, dengan menggunakan bantuan program Ruaumoko berupa program untuk analisis dinamis dua dimensi berdasarkan cara step by step integration method, Dean dan Tjondro mengembangkan secara teoritis analisis untuk bangunan bertingkat sampai dengan 4 lantai.

Perilaku dari dinding geser pada bangunan bertingkat ditest secara teoritis dengan simulasi pada komputer untuk berbagai macam gempa yang diskala setara dengan El Centro 1940 NS, higher mode effects terutama pada bangunan bertingkat tiga dan empat, menunjukkan efek pecut sebesar masing-masing 8 dan 15 % yang direkomendasikan untuk desain statik ekuivalen. Inelastic inter-storey drift yang terjadi harus memenuhi syarat yang diijinkan.

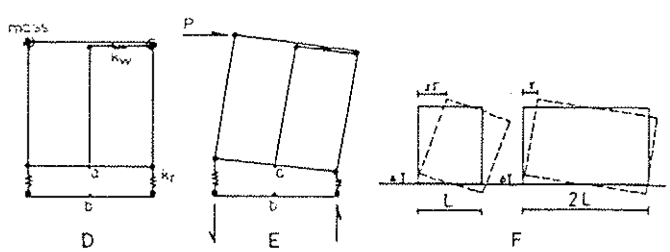
Pada support connections, deformasinya diperhitungkan menyebabkan terjadinya rocking pada dinding geser yang menyebabkan peralihan horisontal yang makin besar (Gambar 7), initial slackness akibat shrinkage dan misalignments waktu pelaksanaan juga ditinjau efeknya.



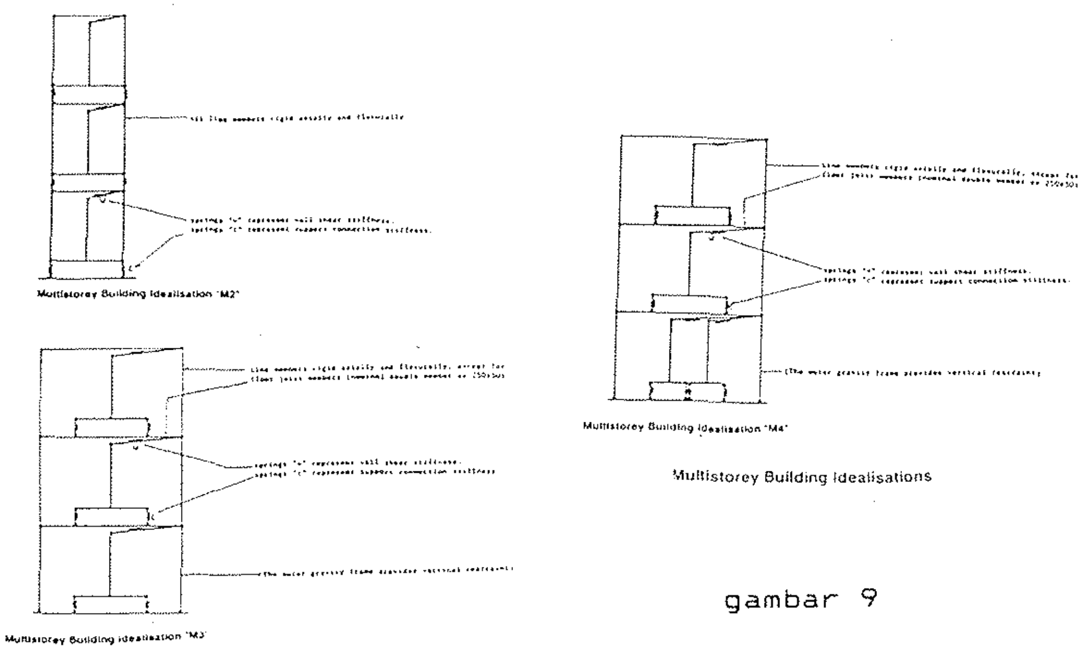
gambar 7

Pada setiap lantai sebenarnya tidak diperlukan jumlah panel dinding geser dengan kekakuan lateral yang sama, hal ini dapat divariasikan dengan berbagai macam ketebalan plywood yang digunakan.

Model-model analisis dikembangkan, rocking direpresentasikan dengan pegas vertikal kr seperti pada gambar 8, dan kekakuan lateral dari dinding dengan pegas horisontal kw, pada bangunan bertingkat model untuk analisis terlihat pada gambar 9, dengan pengembangan dasar analisis untuk single wall seperti pada gambar 8.



gambar 8 Rocking of Shearwalls in Multistorey Buildings



gambar 9

4. Aspek-aspek lain untuk bangunan bertingkat dinding geser kayu

Pada bangunan kayu yang sangat penting adalah detailing dari hubungannya, terutama dimana kita akan membuat struktur menjadi daktail, hal ini sulit dicapai pada material kayu, jadi kelelehan material biasanya didesain terjadi pada bagian sambungan. Hal ini memerlukan detailing hubungan yang benar.

Biaya dari bangunan bertingkat dengan dinding geser kayu dapat menjadi mahal kalau belum merupakan suatu industri dalam memproduksi elemen-elemen strukturnya, terutama di Indonesia yang belum membudaya, jika hasil dan kegunaannya sudah terasakan, industri ini akan berkembang.

Terhadap bahaya kebakaran sebenarnya kayu pada batas tertentu lebih baik dari baja, karena pada saat lapisan arang terbentuk, bagian dalam terlindungi dan berhenti terbakar, tetapi ada kelemahan pada sambungan-sambungan, yanq alat penyambungnya pada umumnya adalah dari baja. Alat penyambung ini harus cukup kuat terhadap bahaya kebakaran ataupun mendapat perlindungan khusus. Riset dalam hal ini sudah banyak dilakukan.

Dari sudut arsitektur bangunan kayu dapat dibentuk secara fleksibel menjadi bangunan yang indah.

5. Kesimpulan dan saran

- Bangunan dinding geser kayu sangat potensial dan cocok untuk dikembangkan di Indonesia, terutama pada daerah-daerah gempa, dengan memperhatikan treatmentnya pada daerah tropis.
- Perilaku daktail pada dinding geser kayu terbatas pada limit daktilitas tertentu.
- Stewart hysteresis curve dapat digunakan dengan parameter/karakteristik dinding geser kayu dengan material produksi Indonesia yang dapat dicari dari test di laboratorium.

Daftar Pustaka:

1. New Zealand Timber Today; volume 2, no 4; volume 13, no 2, 3, 4; volume 14, no 2.
2. Thurston, S.J. and P.F. Flack, Cyclic Load Performance of Timber Sheathed Bracing Walls, Central Laboratories Report No 5 - 80/10, Lower Hutt, New Zealand, November 1980.
3. Dean, J.A and W.G. Stewart, The Seismic Performance of Timber Frame Shearwalls with Gibraltarboard Sheathing, Research Report 84-17, Department of Civil Engineering University of Canterbury.
4. Dean, J.A and J.A. Tjondro, The Seismic Design of Timber Frame Shearwalls Sheathed with Gibraltarboard; Refinements to the CE 87/7 Procedure, Research Report 88-9, Department of Civil Engineering University of Canterbury.