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Preface

Land Consolidation under the national government policy was started in Meiji era. However farms these days were standardized to be more or less 0.1 ha and farm road to be about 1 meter wide assuming the farming based on animal plowing and human labor.

Since 1963, as a result of the remarkable social and economic development the importance of labor productivity in agriculture has been emphasized, and farming in paddy fields has been mechanized in a large scale with progress of farming.

Land Consolidation has been carried out aiming at mechanization of farming, which realize large farm lots more than 0.3 ha in area, farm roads more than 4 meter in width, the perfect separation between irrigation and drainage, and the subsurface drainage as well as the subsoil improvement.

At present, these processes have brought out the planning standard of land consolidation in paddy fields, on the basis of medium and large scale mechanization.

Recently, land consolidation projects covering 50 thousands ha are put in excution every year. Now, for further discussion, I would present some details of land consolidation in paddy fields as related to the latest farm mechanization in Japan.

Field conditions needed for farm mechanization

1. Readjustment of field lots

To promote the working efficiency of farming machine, it is desirable to have the size of each farm lot larger than $30 \text{ m} \times 100 \text{ m} \ (= 0.3 \text{ ha})$, because existing one is too small and not uniform in shape.

2. Improvement of farm road

Main farm roads of 6 to 7 meters in width for bringing machine to field and their branches of 4 to 5 meters in width leading to each field lot should be well distributed along field lots.

3. Improvement of irrigation and drainage facilities

Branch canals for irrigation and drainage should be appropriately distributed along each field lot so as to enable adequate water control according to the operation of machines and cultural management.

4. Subsoil improvement

Subsoil of paddy field should have a sufficient bearing capacity so as to support large size machines with heavy load. In case of clayey soil of poor drainage, it is particularly important to carry out subsoil improvements such as underdrainage or subsoil breaking.

Land readjustment

1. Definition of farmland blocks

Farmland blocks are classified and defined in Japan as follows:

a) Field lot: Lot surrounded by roads, irrigation and drainage canals of fixed

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borders.

b) Field block: Block made up of a group of several field lots arranged in a row. It is surrounded by such permanent and fundamental facilities as roads or irrigation and drainage canals.

c) Farm block: Block surrounded by farm roads. Each farm block, in general, consists of two adjacent field blocks separated from each other by a drainage canal.
 2. Arrangement of farm roads and canals

In readjustment farm lots, irrigation and drainage canals are disposed first; then according to this, farm roads and farm blocks are arranged. Drainage ditches are disposed at right angles with contours in order to diminish cross-sectional area of flow and to minimize construction costs.

The short side of each field lot is to be arranged at right angles with contours in order to minimize soil to be removed in land grading. The mutual arrangement of roads and ditches surrounding each field block is to be decided with consideration of perfect separation between irrigation and drainage canals, free water management in each field lot, and convenience in approaching each field lot from roads.

It is also necessary to minimize the area occupied by farm roads, canals and borders. Table 1 shows the relation between the size of farmland block and the percentage of occupied area. As farmland block expands, the latter decreases.

Short side length	Long side length	Area of field lot	Percentage of occupation area of road, ditch and border
20 m	50 m	0.1 ha	13.2%
25	80	0.2	9.5
20	100	0.2	9.5
30	100	0.3	7.8
40	100	0.4	7.0
50	100	0.5	6. 5

Table 1.Relation of field lot shape to the area occupied
by road, ditch and border

Note: Conditions used for calculation as follows: Farm road width=4 m Total width of irrigation and drainage ditch=5 m Drainage branch canal width=1.5 m Border width=0.5 m By Dr. Shinzawa and Dr. Koide

3. Form and area of farmland blocks

In Figure 1, the long side (a) of field block is limited principally by allowable length of irrigation ditch along the long side. When irrigation ditches branching from irrigation branch canal are too long, irrigation water is not well distributed to each field lot. A length of 300 to 600 meters is generally desirable. A field lot is equivalent to each of 15 to 16 divisions of a field block.

The form and the area of a field lot depend on

a) operation efficiency of machine

b) gradient of land

c) convenience in operating irrigation and drainage system

d) situation of land possession and possibility of its consolidation.

The followings are the main factors to be determined:

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Fig. 1. Definition of farmland blocks in paddy field



Note: R.....Ratio of b to c length (See Fig. 1)

Fig. 2. Relation of field lot area to operation efficiency in field

a) a lower limit of the long side (b) and of the short side (c)

- b) an upper limit of the short side $\left(c\right)$
- c) an upper limit of the long side (b)
- $d) \quad \text{an upper limit of an area of field lot.}$

$1) \quad Operation \ efficiency \ of \ machine$

Operation efficiency of machines concerns tilling, grading, harrowing, fertilizing, seeding and weeding with tractor, pest controlling, and harvesting with combine. Operation efficiency is markedly affected by the form and the area of farmland blocks, so that a field lot is to be decided so as to increase operation efficiency which is mainly influenced by turning of machines, supplying and carrying of materials and subsoil condition. The operation efficiency increases in proportion to the farmland area and the ratio of the long side to the short side. This relation found with the rotary cultivation using a 30 to 40 ps wheel tractor is shown in Fig. 2; when the area exceeds 0.3 ha, the efficiency increases a little, while it decreases remarkably in the area under 0.3 ha. As the long side—short side ratio increases, the efficiency increases

Though distributing of agricultural chemicals, unlike other operations, limits the length of long and short sides, efficient distributing machines will be developed in future.

2) Land inclination

Generally, it is most economical to locate the long side (b) in parallel with contours and the short side (c) at right angles with them. Gradient and undulation of land are the factors limiting the short side (c) mainly because land grading costs are affected by (c). As regards a land inclination, the short side (c) can be freely decided when land is less than 1/500 in gradient. But in case of 1/50, a land inclination is the most important factor to limit the short side.

It is desirable that the level difference of neighbouring paddy fields is within 0.3 meters and it must be kept within 1 meter even in case of a steep-sloped land.

Land grading costs occupy usually about 22% of the total costs of land consolidation project. And in general the percentage increases in proportion to the degree of land inclination as well as the length of the short side (c).

3) Operation of irrigation and drainage systems

Water of paddy field should be controlled freely in each field block in individual farming, and in each farm block in large-scale farming or group farming. So, as shown in Fig. 1, the maximum length of the long side (b) of field lot is often limited by the easiness of water control. As the technique of rice cultivation has advanced the importance of water management has come to be highly recognized. Not only standing water in paddy field but also ground water table should be controlled rapidly.

Then, the excessive length of the long side (b) would make it difficult to level the surface of paddy field and to drain the surface water. It is not good for cultural management that the long side (b) exceeds 100 meters, especially in clayey soil paddy fields of poor drainage.

4) Scale of farm management

The area of field lot is restricted not only by the above-mentioned natural or technical conditions but also by the scale of farm management.

In Japan, a farm holding is averaged about one hectare. Therefore in many cases a field lot of more than 0.3 ha is difficult to be established owing to little possibility of substitution or consolidation of farm land, even though judging from the other conditions, it is appropriate.

		-		(Unit: kg/cm ²)
Land slope	Drainage condition	Short side length	Long side length	Field lot area
Flat zone	Well-drained paddy fields	30—60 m	100—150 m	0.3—0.9 ha
(1/500)	Ill-drained paddy field	30—60	100	0. 3—0. 6
Gentle slope zone	Well-drained paddy field	30	100—150	0. 3—0. 45
(1/500-1/50)	Ill-drained paddy field	30	100	0. 3
Rapid slope zone (1/50)		20—30	100	0. 20. 3

Table 2. Standard shape and area of field lot.

However, where large-scale management or group cultivation can be carried out, the size of holding is no longer a factor determing the area of field lot.

From the facts mentioned above, the present standard field lot in Japan can be shown as in Table 2.

Readjustment of irrigation and drainage

1. Classification of farm road

The farm road in Japan is classified according to the kind, name and function as follows: (Fig. 3)



Fig. 3. Each part related to farm road

a) Main farm road

b) Vertical branch farm road

c) Lateral branch farm road

d) Small farm road

2. Width and height

Farm road must have both a width enough to pass vehicles or farm machines and a width of shoulder on both sides. Each standard width is as follows:

Main farm road: 6 to 7 meters (which enables two trucks to pass each other). Branch farm road: 4 to 5 meters (which enables a combined harvester—thresher to pass).

The width of farm road needed to pass main vehicles or farming machines is listed for references as follows:

Motorcar	1.9 m
Truck (of 5 ton)	$2.4 \mathrm{m}$
Tractor (of 40 ps class)	$2.0 \mathrm{m}$
Trailer	1.9 m
Combined harvester-thresher	
(3 m in reaping width)	$3.5 \mathrm{m}$
Speed duster (of tractor system)	1.9 m

Farm roads higher than field surface are convenient for maintenance, but lower roads give an easy passing of machines between roads and fields, and lower construction costs. The standard should be fixed as follows:

Main farm road 50 cm (height from field surface)

Branch farm road 30 cm (height from field surface)

3. Intersection and tractor passage

At the intersection of two branch farm road, 1.5 meters of the corners are cut off for turning vehicles.

The tractor passage for getting in and out of a field lot should be built on either every lot or every two lots.

For passing combined harvester-thresher, the width of passage should be 4 meters when it is built on every field lot or 6 meters when built on every two lots. The gradient should be less than 18° .

4. Pavement of farm road

Main farm road is mostly paved with asphalt concrete whose thickness is about 5 cm. On the other hand, branch farm road is paved with gravel or crushed stone.

Readjustment of irrigation and drainage

It is general in Japan to readjust irrigation and drainage systems on the occasion of land readjustment.

1. Irrigation canals and ditches

Irrigation ditches abutting on each field lot are distributed either by open channel or by pipe line. Open channel was generally cut into the earth. Concrete lining or flumes have come to be applied in many cases for an easier maintenance.

Pipe line was not common because of its higher construction costs, but it is becoming popular all over the country owing to such benefits as easier maintenance, less occupation areas, water saving and no destruction of machine passage.

2. Drainage canals or ditches

Drainage canals or ditches are in principle of open channel type

In case the soil is apt to break, it is reinforced with fence revetment or stone wall revetment. The sufficient depth would be approximately 40 to 50 cm below soil surface so far as the drainage of rain water is concerned. However, about 1 meter

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is required with the consideration of the underground drainage for increasing a bearing capacity in non-irrigation period, or for keeping the optimum percolation in the irrigation period.

3. Subsurface drainage

It is necessary to construct subsurface drainage in ill-drained paddy fields whose soil has insufficient bearing capacity or whose ground water table is not sufficiently lowered in non-irrigation period. The necessity of underdrainage depends on whether the ground water level lowers to 50 cm below surface within a few days after rainfall or not.

The underdrains are laid at the depth of 0.6 to 1.2 meters after examining soil conditions such as permeability of subsoil layers and development of cracks.

The standard intervals is 5 to 10 meters in case of clayey soils, and about 10 to 20 meters in case of sandy soils.

Earthen or plastic pipes are laid in ditches dug out with trencher, and are wrapped with rice hulls for an effective underdrainage. In addition, heavy clayey soil needs subsoil improvement such as mole drains or subsoil breaking because underdrainage alone can not be sufficiently effective in such soil.

Subsoil improvement

In order to introduce a large scale machine into paddy field and to obtain a stable maximum yield, subsoil miprovement is required as a component of land consolidation.

1. Surface soil removing

In land readjustment to recompose small blocks into large ones, land is graded for levelling the field surface. When more than 15 cm of soil is taken off, the fertile surface soil is once removed and then put back again after subsoil improvement.

As surface soil removing makes readjustment works expensive, it is desirable to avoid it. But when subsoil fertility is remarkably low, or subsoil is sand, gravel or peat, etc. surface soil removing is indispensable.

2. Improvement of soil permeability

High permeability of soil is desirable for machine passage. But too high permeability is undesirable because it increases the percolation rate, resulting in the excessive duty of water.

In the paddy field of higher permeability, it is necessary to prevent percolation by means of soil dressing or subsoil compacting, while in the clayey soil its lower permeability needs to be increased by means of underdrainage and subsoil improvements such as mole drain and subsoil breaking.

3. Bearing capacity of soil

Bearing capacity of soil needed for passing machines in paddy fields varys largely with the type of machines, wheels, attachments and machine works.

bine
rawler
3
-3
-2
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Table 3. Judgement of trafficability by cone index (Unit: kg)cm²)

The simplest indication of cone index and soil resistance in kg/cm^2 , given in Table 3, can be regarded as standard values for machine passage. In improving soil layers, it is aimed to improve subsoil condition so as to maintain these standard values.

4. Land leveling grade

When block is enlarged it becomes more difficult to keep paddy field surface in a well leveled condition, and this causes difficulty in operating machine such as rice planter. Therefore, in land leveling works following a readjustment, the leveling accuracy of paddy field surface is taken to be within the limit of ± 5 cm.

In addition, it is desirable to make the drain side of block, as a whole, lower than the irrigation canal side.

The leveling accuracy of $\pm 5 \text{ cm}$ is just a limit for construction machines such as bulldozer and a higher accuracy should be ensured by repeating leveling works by hand. The experiences so far have shown that a more or less incomplete leveling at the time of construction works can be improved enough to manage the cultivation within a few years.

Recent progress of land consolidation

Land consolidation works are operated by the prefectural government in case the benefit area is over 200 ha and by the land improvement association, or the municipal government in case the benefit area is less than 200 ha.

The cost of land consolidation works amounts to 4 million yen per ha and is to be shared as indicated in the following table:

	The Rate of Share	Reference
The Government	40-50%	
The Prefectures	20-30%	The rate varys according to the financial con- dition of each Prefecture
The farmers	20–30 <i>%</i>	The farmers are provided with such financial aids as long term loans, three year deferred payments, fifteen yearly payments and 5.5 percent interest.

Except these works, the farmers undertake the land consolidation works with aid of long term and low interest loan.

Years	Operated by Prefectures (1, 000 ha)	Others (1, 000 ha)	Total (1, 000 ha)
1963	0.6	20. 5	21. 1
1964	2.5	26.8	29.3
1965	7.1	30. 2	37.3
1966	9. 0	33. 6	42.6
1967	14. 3	32. 9	47.2
1968	17.9	37.2	55. 1
1969	24.0	35.6	59.6
1970	35. 1	31. 3	66.4
1971	41.4	30. 0	71.4
1972	48. 5	28.7	77.2
1973	44. 3	25. 9	70.2
1974	34.0	19.9	53.9
Total	278.5	352.6	630. 9

A total of 600 thousand ha of paddy field have been consolidated since 1963.

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