Randomized Block Design (RBD)

Randomized complete block designs differ from the **completely randomized designs** in that the experimental units are grouped into blocks according to known or suspected variation which is isolated by the blocks.

When the experimental material is heterogeneous, the experimental material is grouped into homogenous sub-groups called blocks. As each block consists of the entire set of treatments a block is equivalent to a replication. If the fertility gradient runs in one direction say from north to south or east to west then the blocks are formed in the opposite direction.

Such an arrangement of grouping the heterogeneous units into homogenous blocks is known as randomized blocks design. Each block consists of as many experimental units as the number of treatments. The treatments are allocated randomly to the experimental units within each block independently such that each treatment occurs once. The number of blocks is chosen to be equal to the number of replications for the treatments.

If all the treatments are applied at random relatively homogeneous units within each strata or block and replicated over all the blocks. The design is a randomised block design.

Advantages of RBD

(i) Accuracy:

This design has been shown to be more efficient or accurate than C.R.D for most types of experimental work. The elimination of between S.S. from residual S.S. usually results in a decrease of error mean S.S.

(ii) Flexibility:

In R.B.D no restriction are placed on the number of treatments or the number of replicates. In general, at least two replicates are required to carry out the test of significance (factorial design is an exception). In addition, control (check) or some other treatments may be included more than once without complications in the analysis.

(iii) Ease of Analysis:

Statistical analysis is simple and rapid. More-over the error of any treatment can be isolated and any number of treatments may be omitted from the analysis without complicating it.

Disadvantages of RBD

i) RBD may give misleading results if blocks are not homogeneous.
ii) RBD is not suitable for large number of treatments in that case the block size will increase and it may not be possible to keep large blocks homogeneous.
iii) If the data on more than two plots is missing, the statistical analysis becomes quite tedious and complicated.

Layout of RBD: -

Let us consider five Treatments A, B, C, D, E each replicated 4 times we divided the whole experimental area into 4 relatively homogeneous block and each in to 5 units the treatments allocated at random to the blocks particular layout may be follows.

$$
\begin{array}{llllll}
Block I & A & B & C & D & E \\
Block II & B & C & D & E & A \\
Block III & C & D & E & A & B \\
Block IV & D & E & A & B & C
\end{array}
$$

Let us assume that y_{ij} is the response of the yield of experiment unit from i^{th} treatment j^{th} block.

		Blocks			*means*	*total*
Treatments	y_{11}	y_{12}	....	y_{1r}	$\bar{y}_{1.}$	$T_{1.}$
	y_{21}	y_{22}	....	y_{2r}	$\bar{y}_{2.}$	$T_{2.}$
	..	...	...	...	...	..
	y_{i1}	y_{i2}	....	$y_{ij} y_{ir}$	$\bar{y}_{i.}$	$T_{i.}$
	...	...	...	...	....	....
	...	...	...	....	....	.....
	y_{t1}	y_{t2}	....	y_{tr}	$\bar{y}_{t.}$	$T_{t.}$
means	$\bar{y}_{.1}$	$\bar{y}_{.2}$	....	$\bar{y}_{.r}$		$\downarrow$
total	$T_{.1}$	$T_{.2}$	....	$T_{.r}$	$\rightarrow$	G

Latin Square Design:

*Introduction:

In RBD whole of the experimental area is divided into relatively homogeneous strata or blocks and treatments are allocated at random to the units within each block. i.e. randomization was restricted, within each block. But in field experimentation, it may happen that experimental area exhibits fertility in strips. E.g. cultivation might result in alternative strips of high or low fertility. RBD will be effective if the blocks happen to parallel to these strips and would be extremely inefficient if the blocks are across the strips. A useful method of eliminating fertility variations in two perpendicular directions consists in an experimental layout which will control variations in two perpendicular directions. Such a layout is called Latin Square Design (LSD).

Example:

Suppose different brands of petrol are to be compared with respect to the mileage per litre achieved in motor cars.

Important factors responsible for the variation in mileage are

- the difference between individual cars.
- the difference in the driving habits of drivers.

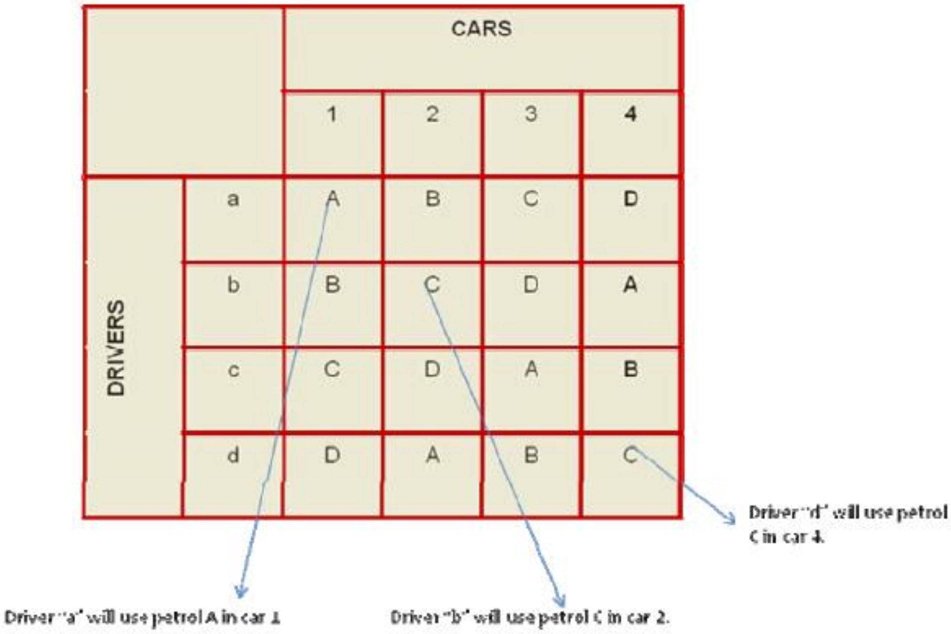
We have three factors – cars, drivers and petrol brands. Suppose we have

- 4 types of cars denoted as 1, 2, 3, 4.
- 4 drivers that are represented by a, b, c, d.
- 4 brands of petrol are indicated as A, B, C, D.

Now the complete replication will require $4 \times 4 \times 4 = 64$ the number of experiments. We choose only 16 experiments. To choose such 16 experiments, we take the help of the Latin square. Suppose we choose the following Latin square:

A	B	C	D
B	C	D	A
C	D	A	B
D	A	B	C

Write them in rows and columns and choose rows for drivers, columns for cars and letter for petrol brands. Thus 16 observations are recorded as per this plan of treatment combination (as shown in the next figure) and further analysis is carried out. Since such design is based on Latin square, so it is called as a Latin square design.



Another choice of a Latin square of order 4 is

C	B	A	D
B	C	D	A
A	D	C	B
D	A	B	C

This will again give a design different from the previous one. The 16 observations will be recorded again but based on different treatment combinations.

Since we use only 16 out of 64 possible observations, so it is an incomplete 3-way layout in which each of the 3 factors – cars, drivers and petrol brands are at 4 levels and the observations are recorded only on 16 of the 64 possible treatment combinations.

Example:

Consider a factory setting where you are producing a product with 4 operators and 4 machines. We call the columns the operators and the rows the machines. Then you can randomly assign the specific operators to a row and the specific machines to a column. The treatment is one of four protocols for producing the product and our interest is in the average time needed to produce each product. If both the machine and the operator have an effect on the time to produce, then by using a Latin Square Design this variation due to machine or operators will be effectively removed from the analysis.

Thus in an LSD,

- the treatments are grouped into replication in two-ways
    - once in rows and
    - and in columns,
- rows and columns variations are eliminated from the within treatment variation.
    - In RBD, the experimental units are divided into homogeneous blocks according to the blocking factor. Hence it eliminates the difference among blocks from the experimental error.
    - In LSD, the experimental units are grouped according to two factors. Hence two effects (like as two block effects) are removed from the experimental error.
    - So the error variance can be considerably reduced in LSD.

*Layout of LSD:

In field-plot experiments, the Latin square is usually laid out in the conventional square with the rows and columns corresponding to possible fertility trends in two directions across the field. In other types of experiments, the rows and columns may correspond to different sources of error as in an animal feeding experiment where the column groups may correspond with initial weight and the row group with age.

In LSD the number of treatments is equal to the number of replications. Thus in case of m treatments, there have to be m x m = m^2 experimental units, arranged in a square so that each row as well as each column contains m units (plots). The m treatments are then allocated at random to these rows and columns in such a way that every treatment occurs once only once in each row and in each column. Such a layout is called m x m Latin Square Design. (L.S.D.)

Obviously there can be many arrangements for an m x m L.S.D. and a particular layout in an experiment must be determined randomly.

Standard Latin square:

A Latin in which the treatments say A, B, C etc occur in the first row and first column in alphabetical order is called standard Latin square.

For 2 x 2 layout,

A	**B**
B	**A**

For 3 x 3 layout,

3x3 layouts

A	**B**	**C**
B	**C**	**A**
C	**A**	**B**

For 4 x 4 layout,

Example: Four standard forms of 4×4 Latin square are as follows.

A B C D	A B C D	A B C D	A B C D
B A D C	B C D A	B D A C	B A D C
C D B A	C D A B	C A D B	C D A B
D C A B	D A B C	D C B A	D C B A

Advantages of LSD

1. With two way grouping LSD controls more of the variation than CRD or RBD.
2. The two way elimination of variation as a result of cross grouping often results in small error mean sum of squares.
3. LSD is an incomplete 3-way layout. Its advantage over the complete 3-way layout is that instead of m^3 experimental units only m^2 units are needed. Thus, a 4x4 LSD results in saving of $m^3 = 4^3 - 4^2 = 64-16 = 48$ observations over a complete 3-way layout.
4. The statistical analysis is simple though slightly complicated than for RBD. Even 1 or 2 missing observations the analysis remains relatively simple.
5. More than one factor can be investigated simultaneously.

Disadvantages of LSD

1. LSD is suitable for the number of treatments between 5 and 10 and for more than 10 to 12 treatments the design is seldom used. Since in that case, the square becomes too large and does not remain homogeneous.
2. In case of missing plots the statistical analysis becomes quite complex.
3. If one or two blocks in a field are affected by some disease or pest. We can't omit because the number of rows columns and treatments have to be equal.