BIBD examples 19.9, 19.10 section 19.4

```
options nodate nonumber ls=80 nocenter;
data pillow;
input Consumers     Treatment $   Comfort @@;
cards;
1      A      59     1      B      26     1      C      38     2      D      85     2      E      92
2      F      69     3      G      74     3      H      52     3      I      27     4      A      63
4      D      70     4      G      68     5      B      26     5      E      98     5      H      59
6      C      31     6      F      60     6      I      35     7      A      62     7      E      85
7      I      30     8      B      23     8      F      73     8      G      75     9      C      49
9      D      74     9      H      51     10     A      52     10     F      76     10     H      43
11     B      18     11     D      79     11     I      41     12     C      42     12     E      84
12     G      81
;


proc glm;
class consumers treatment;
model comfort = consumers treatment / ss3;
means treatment;
lsmeans treatment / pdiff cl lines;
run;
```

The SAS System

The GLM Procedure

Class Level Information

Class	Levels	Values
Consumers	12	1 2 3 4 5 6 7 8 9 10 11 12
Treatment	9	A B C D E F G H I

Number of Observations Read 36
Number of Observations Used 36

The SAS System

The GLM Procedure

Dependent Variable: Comfort

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	19	16302.33333	858.01754	24.57	<.0001
Error	16	558.66667	34.91667		
Corrected Total	35	16861.00000			

R-Square	Coeff Var	Root MSE	Comfort Mean
0.966866	10.27658	5.909033	57.50000

Source	DF	Type III SS	Mean Square	F Value	Pr > F
Consumers	11	454.33333	41.30303	1.18	0.3694
Treatment	8	11727.33333	1465.91667	41.98	<.0001

The SAS System

The GLM Procedure

Level of Treatment	N	Comfort Mean	Comfort Std Dev
A	4	59.0000000	4.96655481
B	4	23.2500000	3.77491722
C	4	40.0000000	7.52772653
D	4	77.0000000	6.48074070
E	4	89.7500000	6.55108134
F	4	69.5000000	6.95221787
G	4	74.5000000	5.32290647
H	4	51.2500000	6.55108134
I	4	33.2500000	6.13052472

The SAS System

The GLM Procedure
Least Squares Means

Treatment	Comfort LSMEAN	LSMEAN Number
A	61.5000000	1
B	20.1666667	2
C	40.8333333	3
D	75.8333333	4
E	86.8333333	5
F	70.8333333	6
G	75.5000000	7
H	50.1666667	8
I	35.8333333	9

The SAS System

The GLM Procedure
Least Squares Means

Treatment	Comfort LSMEAN	95% Confidence Limits	
A	61.500000	54.368925	68.631075
B	20.166667	13.035592	27.297741
C	40.833333	33.702259	47.964408
D	75.833333	68.702259	82.964408
E	86.833333	79.702259	93.964408
F	70.833333	63.702259	77.964408
G	75.500000	68.368925	82.631075
H	50.166667	43.035592	57.297741
I	35.833333	28.702259	42.964408

Least Squares Means for Effect Treatment

i	j	Difference Between Means	95% Confidence Limits for LSMean(i)-LSMean(j)	
1	2	41.333333	31.105416	51.561251
1	3	20.666667	10.438749	30.894584
1	4	-14.333333	-24.561251	-4.105416
1	5	-25.333333	-35.561251	-15.105416
1	6	-9.333333	-19.561251	0.894584
1	7	-14.000000	-24.227918	-3.772082
1	8	11.333333	1.105416	21.561251
1	9	25.666667	15.438749	35.894584
2	3	-20.666667	-30.894584	-10.438749
2	4	-55.666667	-65.894584	-45.438749
2	5	-66.666667	-76.894584	-56.438749
2	6	-50.666667	-60.894584	-40.438749
2	7	-55.333333	-65.561251	-45.105416
2	8	-30.000000	-40.227918	-19.772082
2	9	-15.666667	-25.894584	-5.438749
3	4	-35.000000	-45.227918	-24.772082
3	5	-46.000000	-56.227918	-35.772082
3	6	-30.000000	-40.227918	-19.772082
3	7	-34.666667	-44.894584	-24.438749
3	8	-9.333333	-19.561251	0.894584
3	9	5.000000	-5.227918	15.227918
4	5	-11.000000	-21.227918	-0.772082
4	6	5.000000	-5.227918	15.227918
4	7	0.333333	-9.894584	10.561251
4	8	25.666667	15.438749	35.894584
4	9	40.000000	29.772082	50.227918
5	6	16.000000	5.772082	26.227918
5	7	11.333333	1.105416	21.561251
5	8	36.666667	26.438749	46.894584
5	9	51.000000	40.772082	61.227918
6	7	-4.666667	-14.894584	5.561251
6	8	20.666667	10.438749	30.894584
6	9	35.000000	24.772082	45.227918
7	8	25.333333	15.105416	35.561251
7	9	39.666667	29.438749	49.894584
8	9	14.333333	4.105416	24.561251

LS-means with the same letter are not significantly different.

	Comfort LSMEAN	Treatment	LSMEAN Number
A	86.83333	E	5
B	75.83333	D	4
B	75.50000	G	7
C B	70.83333	F	6
C	61.50000	A	1
D	50.16667	H	8
E D	40.83333	C	3
E	35.83333	I	9
F	20.16667	B	2

Balanced Incomplete Block Design (BIBD)

- If all treatment comparisons are of equal importance and if we wish to estimate each treatment effect with the same precision, then the design needs to be **balanced**:

  (1) Each block contains the same number of units.

  (2) Each treatment occur the same number of times in total

  (3) Each pair of treatments occurs together the same number of times in total.

- A design that satisfies these conditions is called **Balanced Incomplete Block Design.**