

RECTIFICATION EXAM D2 AS 2020

Problem 2

Module:	D2, Design and Analysis of Experiments
Date of exam:	15.03.2021, 08:30-10:30 am
Duration:	2x 45 min
Type of exam:	Open book: Distributed printed course material allowed, personal notes allowed, laptop allowed, access to Internet allowed, pocket calculator allowed. Any form of oral or electronic communication with other students or persons from outside is forbidden. Furthermore, Videos and Screencasts are not allowed.
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School: **ZHAW**

Venue of exam: *online examination upload/download on Moodle*

Declaration of Independent Work

By taking part to this exam, I hereby affirm that the examination is my own work and that I have not used any sources other than those explicitly allowed for the exam. Furthermore, I have not assisted any other students with their online examination.

Exam Briefing

- Write your name and affiliation on the first page
- Next to each problem, the number of points is indicated in parentheses, e.g. (3). Partial credit can be accredited for partially correct answers.
- The level of significance is 5%. Give numeric results (such as p values) to at least three digits.
- Always include a short reasoning (e.g. I applied a marginal F-test and obtained a p value of ... , and therefore I conclude“)
- **Report all your answers on this document. Convert it as a PDF file before submission.**

Best of luck!

Problem 2

A concrete-producing company wants to test the stability of two new systems of concrete production.

Several **independent** and **controlled** concrete samples were produced using **different** material mix and different temperatures during the concrete hardening phase.

After the production and hardening phases, each concrete sample underwent a standardized stress test to determine the pressure at which the sample breaks.

The data set **stress_data** contains the results of the experiment:

- **stress** measures the breaking point of a concrete sample in N/m²
- **mix** indicates the mix of materials used
- **temp** indicates the temperature during the hardening phase

Set your working directory appropriately and import the data set using for e.g.:

```
mydata2 <- readRDS("stress_data.rds")
```

1. Is the design balanced? Does it have a special name? (1)

The design is balanced since we have each of the two treatment (temp) combinations five

times. We call the design a factorial randomized design with replications

structure.

```
mydata1 <- readRDS("stress_data.rds")
```

```
str(mydata1)
```

```
summary(mydata1) #balanced design
```

```
with(mydata1, tapply(output, vacuum, mean))
```

2. Give the **R** code to produce suitable graphical representations of the data set. What do you observe? (3)

```
library(ggplot2)
```

```
ggplot(mydata1, aes(y=stress, x=mix, col=temp)) + geom_point()
```

We can see that the mix of materials “A” used have higher stress outputs than “B”. Furthermore, we can observe that mix of materials A with temp I produce higher stress outputs. A possible interaction between temp and mix of materials might exist.

3. The experiment allows to address three specific questions concerning the effect of mix and temperature on concrete stability: which ones (in words)? (1)

The aim of this model is to model the effect of the different mix materials and the different temperature on the stress output. We have to check assumptions of our model in Independent observations, Normality of Variances and Homoskedasticity.

4. Give the **R** code to fit a suitable parametric model to this data set. (1)

```
mydata1.lm = lm(stress~mix*temp, data=mydata1)
summary(mydata1.lm)#overall f test, for p-value: 0.01165, significant!
library(car)
Anova(mydata1.lm, type=2) #partial F test
```

5. Can you simplify the model above? Name the tools you use and give your **R** code. Report the p-values and use them to answer the question. (2)

```
mydata1.lm = lm(stress~mix*temp, data=mydata1)
summary(mydata1.lm)#overall f test, for p-value: 0.01165, significant!
library(car)
Anova(mydata1.lm, type=2) #partial F test
```

The overall F-test gave a significant value of 0.01165, hence we cannot simplify the model further. A interaction effect between the two factors mix and temp is observed, due to the p value of 0.008656.