

Calibration of (the correction factor) Design Builder program

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Methodology Research

- 1-The importance of calibration of environmental simulation program.
- 2- Overview about Design Builder program.
- 3- Calibration Methodology.
- 4- Practice case study.
- 5- The definition of the building (Detailed description of the case).
- 6- The required data for doing the simulation model.
- 7- The results of Design builder calibration program(A comparison between the readings of electricity meter and the simulation program results).
- 8- The conclusion.

Abstract: The research discussed the importance calibration environmental simulation program, then an overview about Design Builder program. In addition to clarification the methodology that will study with, by doing a practical study case to the building of "El- Wasta prep school for girls" in "El-WastaBeniSuef" with detailed description and input its data and simulation to the program. Thence making a comparison between the readings of electricity meter and the simulation program results. The research aims to determine the actual error rate in Design Builder program results. That happens by doing an actual study to electricity consumption of "EL-Wastaprep school for Girls " building, and compare it with the results of Design Builder simulation program. These studies be done by making daily field visit to the school building and reading its electricity meter monthly. Thence input school data to the Design Builder program and compare it with the actual results of meter's reading, to reach for the error rate of the program results.

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Key words: Calibration, Design, Builder program

Introduction

There are many of thermal performance simulation programs and energy consumption in buildings, however that there are a few of these programs which can do a complete simulation to the building and its external casing. So the Design Builder program be chosen for this experiment, that it accredited by the National Center for Research on Housing and Construction. In addition to that it was used in Egyptian Energy code and uses (Energy plus & Visual DOE4) turbine which been accredited by the United Kingdom since 2010¹.

One of the researchers "engineer Mohammed Abd El Razik" in the National Center for Research on Housing had made a dissertation titled "Method to evaluate energy capacity in administrative buildings" which gave standards to visual "DOE4" turbine, but it didn't make a calibration of Design Builder program in general. This program was used in that dissertation to evaluate a possible solutions to energy conservation through building casings and adjust temperatures of

running air-conditions and others, which helps to improve the overall performance of the building.

Therefore it was necessary to calibrate the used program to exit the factor of correction.

The affective factors on the simulation results difference from the building actual situation

Although the programs been tested and approved, theoretically and technically which includes "a used laws and rates" before its usage, but also there are unnoticed hypotheses for each model which might be axiomatic. The reality of human behavior and the societies difference in our countries from analogical cases that leads to many variations. **There are many of affective factors just for example:**

1- The status of doors and windows while running air-conditioners (open or closed in which proportion).

2- Case in fusion for doors and windows allowing air leaking.

3- Time running air conditions and lighting in the absence of users in vacuum.

4- Durations of power out age.

5- The effect of clothing worn by users on the results (which can not be measured).

6- The user physiological case weight (obesity), kind of activity, age, diet, health status and gender (male or female).

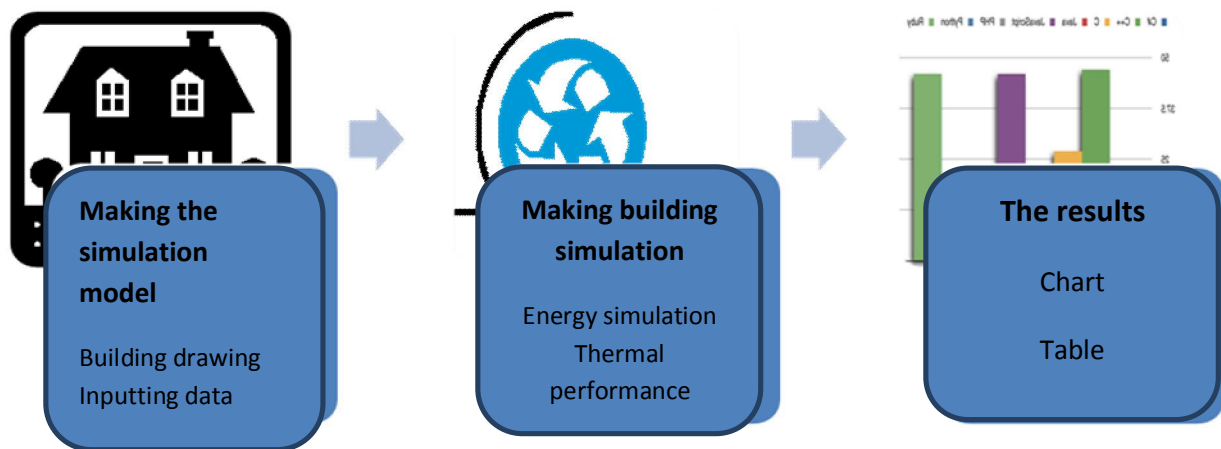
SO before we start to conduct simulation tests, we should check with the assumptions and effects prevailing in that country, zone and building, and measuring the difference between the coefficient of performance of the building in the program and in fact.

Overview about the program:

The design builder program calculates cooling and heating systems, by integration of mechanical and natural system. The program also calculates the amount

of artificial light needed by the building to achieve visual comfort, by incorporating artificial lighting gradually as natural as needed during daylight hours. This program contains all the Egyptian climate data for the regions (city climate of each region),and gives results each hour which gives the user a detailed picture of the way of building performance.

The following figure (1) shows the usual arrangement for the performance of the simulation process, Firstly, three dimensional models makeris used for drawing the building and its components to the application of simulation. Finally results come out in the form of a chart or table.



Calibration methodology;

This research discusses real studies of electricity consumption in "ELWasta prep school for Girls" to compare electricity consumption results from Design Builber simulation program with the real consumption. Therefor determine the actual error rate in program results,with the following steps;

- 1-Making a daily field visit to the school building and definition the number of used electronic sets, lights and its usage hours.
- 2-Readingschool electricitymeter monthlly,and defining reading compartion for knowing monthlly consumption.
- 3-Inputting school data in Design Builder program with three dimentional drawing,in addition to inputting climate data,numbers of electronic sets,numbers of lights and its usage hours.
- 4-comparing the results of the program to define the error rate on it.

2-1-A detailed description of the condition of the building:

EL-Wasta Prep school for Girls is located in " EL-Wasta –Beni Suef" Northen Upper Egypt province which includes "Fayom,Minia and Beni Suef".The building surrounded by streets from all directions and be in the middel of residential area. The building consists of ; on ground floor,a director office,some administative offices and W.C. then on first floor is a library,laboratory,an attached store to the lab and preparation room. Secondfloor consists of three classrooms,there are five floors.

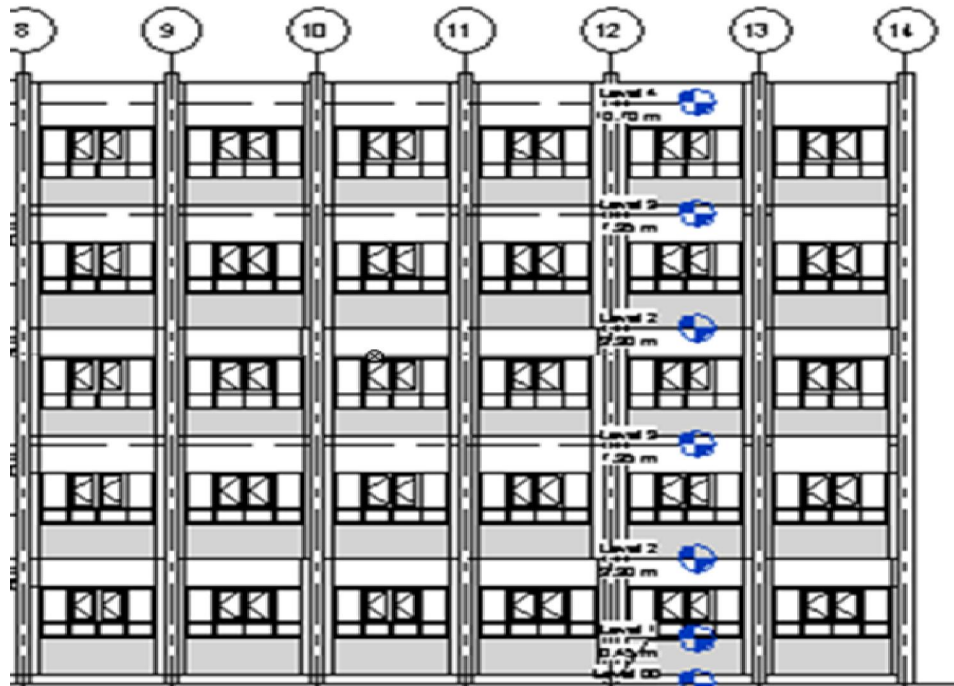
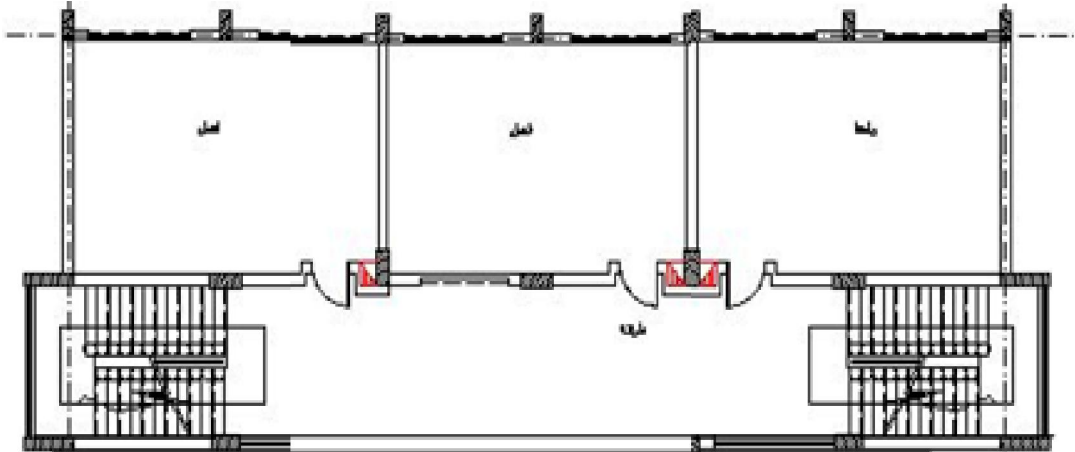


NO.1 A horizontal figure of school model,from Educational Building (BeniSuef)

Picture NO.1 for EL-Wasta Prep School

The building is a rectangular shape its dimensions are (width 7,5 m and length 35 m) in all it is 224 m² and the floor high is 3,5 m. The classrooms are located in the northern direction of the building in dimensions 8*5 m for each class and an aisle 2,5 m over the

building length. The overtures measurement amount in northern frontage about 28% from the whole frontage, which includes about eminent pillars that repeated each 4 m. The southern frontage is a carried aisle on pillars which contains the classrooms doors and has an upper window.



NO.2 The northern frontage of the school building (from Educational Buildings- BeniSuef)

2-2- The required data for making simulation model:

1- Adjusting occupancy hours;

In studying time working starts from 8 a.m, during the day the number of occupants is unchangeable, and ends at 2 p.m. After two o'clock there is not any body in the building unless the cleaners

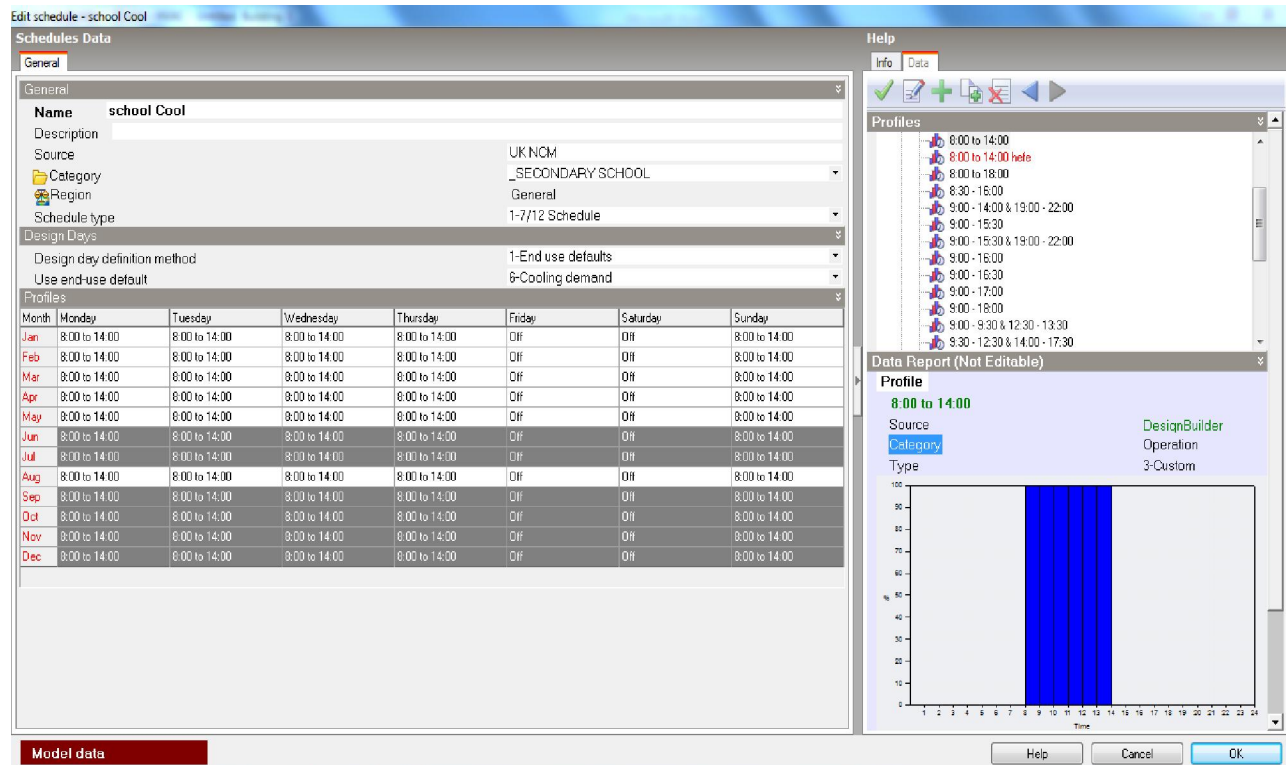
till 3p.m, after that be only the resident school guard. (Table NO.1)

It has been identified the weekends (Friday and Saturday) also the legal holidays (Feasts and Events).

The classrooms are being occupied from 20 September to 30 June, 6 hours daily, but the administrative offices still working all the year.

The following table explains inputting working hours in the building to the program.

| Place \ Day | Educational vacancy | Administrative offices | The guard room | General site |
|-------------|---------------------|------------------------|-----------------------------|-----------------------------|
| Saturday | Not working | Not working | Working from 6 a.m to 8 p.m | Working from 8 p.m to 6 a.m |
| Sunday | From 8a.m to 2 p.m | From 8a.m to 2 p.m | From 6 a.m to 8 p.m | From 8 p.m to 6 a.m |
| Monday | From 8a.m to 2 p.m | From 8a.m to 2 p.m | From 6 a.m to 8 p.m | From 8 p.m to 6 a.m |
| Tuesday | From 8a.m to 2 p.m | From 8a.m to 2 p.m | From 6 a.m to 8 p.m | From 8 p.m to 6 a.m |
| Wednesday | From 8a.m to 2 p.m | From 8a.m to 2 p.m | From 6 a.m to 8 p.m | From 8 p.m to 6 a.m |
| Thursday | From 8a.m to 2 p.m | From 8a.m to 2 p.m | From 6 a.m to 8 p.m | From 8 p.m to 6 a.m |
| Friday | Not working | Not working | From 6 a.m to 8 p.m | From 8 p.m to 6 a.m |



NO.3 Window of adjusting working hours from Design Builder program

2- Construction materials:

The following table (NO. 2) explains the materials used in finishing the external and internal walls of the building, and in the roofs between the floors.

Table NO.2 the finishing materials of the building,from Educational Buildings

| | Finishing |
|------------------------------|--|
| External walls | 2 cm. paint + 25 cm. bricks + 2 cm. paint |
| Internal walls | 2 cm. paint + 25 cm. bricks + 2 cm. paint |
| External roof | 2 cm. tiles + 2 cm. cement + 5 cm. sands + 5 cm. concrete + 5 cm. insulation Polystyrene + 7 cm. concrete cement + 2 cm. insulation moisture Bitumen +15 cm. concrete slab +2 cm finishing |
| Internal roof between floors | 2 cm. tiles + 2 cm. cement + 5 cm. sands +15 cm. concrete slab + 2 cm. finishing |
| GroundFloor | 2 cm. tiles + 2 cm. cement + 5 cm. sands +5 cm. concrete+ 2 cm. insulation moisture Bitumen+ 15 cm. concrete cement + debris |

3-The openings:

There are opening in northern frontage which each one is 7, 8 m² that be 28% from "Window to Wall racho" and 20% from "Window to area flower racho". The following table explains openings found in various frontages of the school building.

Table NO.3 description of school building openings,from Educational Buildings

| Openings | Description |
|---|--|
| Openingsin northern frontage (classrooms) | Single transparent glass window its dimensions 2,60*1,5 m constant,1,3 *1,1 m movable and 1,1 m session high |
| Openingsinsouthern frontages | Single transparent glass window its dimensions 2,60*1,5 m constant,1,3 *1,1 m movable and 1,1 m session high |
| Openingsineastern frontages | NOT found |
| Openingsinwestern frontages | NOT found |

4-The lighting modes:

There are 4 Fluorescent lights in each classroom (picture NO. 1-5), some classroom have a saving electricity lump, in addition to searchlights on school rail. The following table (4-5)explains usage hours of the lighting.



Picture NO. (1-5) the lightings in school, from the researcher

5-HVAC Systems:

The school uses natural ventilations (picture NO.2-5), in addition to roof fans in classrooms and offices (picture NO.3-5), and there are air conditions in computer and fair laboratories



Picture NO.(2-5) the natural ventilation window, From researcher



Picture NO. (3-5) the roof fan in classrooms, from researcher

6-Adjusting sets and equipment used in school:

The researcher had been done a daily field visit to the school for six months from July to January, and she identified the usage hours of all sets. **Following table explains the used sets and its usage hours;**



Picture NO.4-5 the sets in computer lab, from researcher

Table NO.3-5 the sets usage hours in various spaces during the year, from researcher

| Place | lighting | | Artificial ventilation | | | | Sets and equipment | | | |
|----------------------|---------------------------------------|-------------|------------------------|-------------|-------|-------------|--------------------|-------------|-------------------------------|-------------|
| | Lights | Usage hours | Fans | Usage hours | AirC. | Usage hours | Computer | Usage hours | Sets | Usage hours |
| Classes | 4 fluorescent lights 120 cm. | 6 | 2 | 6 | - | - | - | - | - | - |
| Library | 4 fluorescent lights 120 cm. | 6 | 2 | 6 | - | - | 1 | 6 | - | - |
| Computer lab | 4 fluorescent lights 120 cm. | 6 | 2 | 3 | 1 | 3 | 20 | 6 | - | - |
| Multimedia lab | 4 fluorescent +2saving lights 120 cm. | 6 | 1 | 3 | 1 | 3 | 1 | 3 h +30min | Data show+ screen + video +TV | 1 h +40 min |
| Administration | 2 saving lights | 6 | 1 | 6 | - | - | - | - | 10 water heater | - |
| General site | 3 searchlights on school rail | 10 | - | - | - | - | - | - | Microphone +bell | 15min |
| House handcraft room | 2 saving lights | 6 | 2 | 6 | - | - | - | - | Refrigerator+ sewing machine | 24h |
| Minimarket | saving light | 6 | 1 | 6 | - | - | - | - | Refrigerator+ freezer | 24h |
| Guard room | saving light | 8 | - | - | - | - | - | - | - | - |

Table NO. 4-5 number of usage hours of sets and equipment during the week, from researcher

| DAY | lighting | | Artificial ventilation | | | |
|-----------|-----------------|-------------|------------------------|-------------|------------------------|-------------|
| | Lights number | Usage hours | Fans numbers | Usage hours | Air Conditions numbers | Usage hours |
| Saturday | 1 | 8 | - | - | - | - |
| | 3 search lights | 10 | - | - | - | - |
| Sunday | 24 | 6 | 11 | 6 | 2 | 3 |
| | 3 search lights | 10 | - | - | - | - |
| Monday | 24 | 6 | 11 | 6 | 2 | 3 |
| | 3 search lights | 10 | - | - | - | - |
| Tuesday | 24 | 6 | 11 | 6 | 2 | 3 |
| | 3 search lights | 10 | - | - | - | - |
| Wednesday | 24 | 6 | 11 | 6 | 2 | 3 |
| | 3 search lights | 10 | - | - | - | - |
| Thursday | 24 | 6 | 11 | 6 | 2 | 3 |
| | 3 search lights | 10 | - | - | - | - |
| Friday | 1 | 8 | - | - | - | - |
| | 3 search lights | 10 | - | - | - | - |

| DAY | Sets and equipment | | | |
|-----------|--------------------|-------------|-------------------------------|-------------|
| | Computer numbers | Usage hours | Sets and equipment | Usage hours |
| Saturday | | | 2 Refrigerator+ Deep freezer | 24 h |
| Sunday | 22 | 6 | 2 Refrigerator+ Deep freezer | 24h |
| | | | Datashow+ screen +video +TV | 1h+40min |
| Monday | 22 | 6 | 2 Refrigerator+ Deep freezer | 24h |
| | | | Data show + screen +video +TV | 1h+40min |
| Tuesday | 22 | 6 | 2 Refrigerator+ Deep freezer | 24h |
| | | | Data show + screen +video +TV | 1h+40min |
| Wednesday | 22 | 6 | 2 Refrigerator+ Deep freezer | 24h |
| | | | Data show + screen +video +TV | 1h+40min |
| Thursday | 22 | 6 | 2 Refrigerator+ Deep freezer | 24h |
| | | | Data show + screen +video +TV | 1h+40min |
| Friday | - | - | 2 Refrigerator+ Deep freezer | 24h |
| | | | Data show + screen +video +TV | |

The results of Design Builder program calibration:

The following table explains the electricity consumption results by reading electricity meter and Design Builder simulation program from July 2014 to June 2015, which appears the coincidence between the real electricity consumption and the Design Builder

results. The highest error rate is 3,5 % and the least error rate is 2,9 %, therefore the average rate is 3,17 %, which gives a good sign about the data and the ability of using the program in analysis of various alternatives for energy conservation in study case and determines the extent of saving in consumption.

Table NO. 5-5 electricity consumption results by reading electricity meter and Design Builder simulation program from July 2014 to June 2015

| Months | Electricity meter readings (K.W. IN H.) | Electricity consumption by Design Builder | Error rate |
|----------------|---|---|------------|
| July 2014 | 483 | 466 | -3,5 % |
| August 2014 | 451 | 435 | -3,5 % |
| September 2014 | 479 | 462 | -3,5 % |
| October 2014 | 343 | 332,7 | -3% |
| November 2014 | 255 | 247,6 | -2,9 % |
| December 2014 | 203 | 196 | -3 % |
| January 2015 | 214 | 207,58 | -3 % |

The conclusion:

The research had made a calibration of (EL Wasta prep school for Girls) through comparing the electricity consumption results by reading electricity meter and Design Builder simulation program from July 2014 to June 2015, which appears the coincidence between the real electricity consumption and the Design Builder results. The highest error rate is 3,5 % and the least error rate is 2,9 %, therefore the average rate is 3,17%, which gives a good sign about the data and the ability of using the program in analysis of various alternatives for energy

conservation in study case and determines the extent of saving in consumption.

The recommendations:

1- The research recommends with using the Design Builder program which has an acceptable error rate (3, 17 %).

2-The research recommends with adding the error rate to the program results to have the actual results.

3-The research recommends with making a calibration to the simulation program before using it to reach the error rate in it.

9/17/2015