WEST African Journal of Building and Road Research Vol. 1 (3) 2017, pp. 1-13

Empirical study on rainfall patterns and construction programme provisions in Jos, Nigeria

OLUBAJO, O. O and OLAWUYI, B. J
Department of Building, Federal University of Technology Minna,
Corresponding author's email: builderolubajo@gmail.com

ABSTRACT

Weather conditions affect the duration and cost of construction activities while many companies have neglected the need to consider the exact empirical effect it has on the delivery of construction projects. This prompted an investigation on the precipitation patterns in Jos Metropolis of Plateau State, Nigeria and its effects on the delivery of construct3ion projects. The study evaluated the amount and frequency of yearly precipitation in Jos, and compared it with the provisions made by Builders and Construction Managers in preparing construction programmes and determined its effect on the construction projects delivery. A Mixed design approach was adopted with Rainfall data collected from the Nigerian Meteorological Agency for over a 10 year period as well as from structured questionnaires. The Data was analysed using mean and percentages. The study concluded that the provisions made for idle or rain days in preparation of work programmes for construction projects were in most cases inaccurate and thus affected the performance of the construction projects. The study suggests measures to be adopted by stakeholders towards better project outcome.

Keywords: Precipitation, Climate change, Weather, Construction Projects and Work programmes**.**

INTRODUCTION

Climate change increases the risk of embarking on construction projects and has been defined by (Pachauri *et al*., 2007) as modifications in the state of the weather over a long period of time. Bello *et al*. (2012), also defined climate change to be the result of variations in weather conditions such as temperature, wind patterns, precipitation, and relative humidity. Weather events have been known to delay transport and delivery of materials; affecting site programming, costs, and availability of various construction materials (Carbon Disclosure Project - CDP, 2010). Precipitation has been reported to be one of the main factors causing delay and cost overruns on construction projects (Baldwin *et al*., 1971; Koehn and Meilhede, 1981; Laufer and Cohenca, 1990). Precipitation is described as water in a solid or liquid form that falls from the sky to the earth's surface under the influence of gravity. Ewona *et al*,, (2014) classified precipitation by form, type, intensity, and character, however it is the product of condensed atmospheric water vapour; which includes drizzles, rain, sleet, snow, glaze and hail. Precipitation affects many aspects of work on a construction site such as quality, timely completion of activities, and the capacity of site-based personnel to meet the objectives of procedures and plans (Makulsawaudom and Emsley, 2001). Precipitation causes reworks on a construction project and reworks adversely affects the productivity of labour on the site leading to large amounts of unproductive and wasted time (Makulsawaudom and Emsley, 2001, Alinaitwe *et al*., 2007). In Summary construction projects are carried out in outdoor environments and therefore are affected by weather conditions. The effects on the construction process are usually labour-dependent

activities (Thomas and Yiakoumis, 1987; Koehn and Brown, 1985). Extreme weathers affect the health and safety of site workers and labourers and this will in turn delay site construction activities and associated costs (CDP, 2010). Research has confirmed that 50% of construction activities are sensitive to weather conditions (Benjamin *et al.*, 1973). The impact of weather on construction activities can be in the form of reduced labour productivity, quantifying this impact is, clearly, valuable to contractors in preparing realistic schedules, cost estimates, and reliable bids. The productivity loss due to the impact of weather on construction activities can be either partial or total; a partial loss is generally attributed to reduced labour productivity while total loss implies work stoppage which interrupts those activities.

This study determines the climatic variations of rain in Jos based on empirical data for a period of 11years and compared their averages with the provisions made by builders, construction managers, project managers and other key personnel involved in construction scheduling. Construction scheduling or planning has been described as the overall co-ordination and control of a construction project from inception to completion with the aim of meeting a client's requirements functionally and financially that will be completed on time within authorized cost and to the required quality standards (Hendrickson, 2008). The rainfall intensity duration-frequency (IDF) relationship is commonly required for planning and designing of various resource-based projects (El-sayed, 2011). Knowledge about Short term weather and long term climate conditions are essential to adequately design and successfully manage construction projects (National Oceanic and Atmospheric Administration - NOAA, 2010**).** The previous experience of projects provides basic planning logic. Then difference between previous projects and current projects shall be known to make any exceptional features in the basic planning logic. Long term climate impacts, such as sea level rise, coastal erosion, and drought, and short term weather related impacts, such as high winds and flooding influence the choice of site for construction, building techniques, and materials for construction.

PRECIPITATION PATTERN IN NIGERIA

Nigeria has a tropical climate and the amount and intensity of rainfall received in any location is a function of the climate. Two major seasons exist in Nigeria namely; the wet or raining season and the Harmattan or dry season. Two transition periods usher in these seasons, and they are as follows:

- (April to October) – This period represents the wet or raining season in Plateau, Nassarawa and most parts of the country and accounts for about 75% of the total annual rainfall. Steady rains commence in April under the influence of the Humid Tropical Maritime Air mass also known as the South-West Monsoon. Rainfalls in the tropics are generally attributed to frontal, convection or orographic precipitation. The Frontal rainfall occurs when the dry intercontinental air mass comes in contact with the maritime air mass thereby resulting in cooling, condensation and rainfall. The point at which these two air masses meet on land is called Inter Tropical Discontinuity (ITD), and the precipitation patterns are determined by this meeting position.
- (November-March) – This period represents the Dry season. Cold and dusty Harmattan winds commence in November as a result of the Tropical continental air mass or North-East

Monsoon. The ITD continues northward till March so that by April the land comes under the influence of moist Maritime air Mass, (Ayoade, 1983; Binbol, 2007).

It is worthy to note that Jos experiences fog and mist also categorised as suspensions and hail stones which is another form of precipitation.

RESEARCH METHODOLOGY

A descriptive design was adopted for the study and a mixed research approach was chosen to combine both qualitative and quantitative data. The study area selected for this research is Jos Metropolis of Plateau State, North Central Nigeria (Figure 3.1) and records of daily precipitation were obtained for the period of 11 years (2005 – 2015*)* from the Nigerian Meteorological Agency, Abuja for Jos. Builders, Construction Managers and Civil Engineers involved in construction planning formed the population of the study. A purposive sampling technique was chosen to gather data from ongoing and completed construction projects in Jos Metropolis.

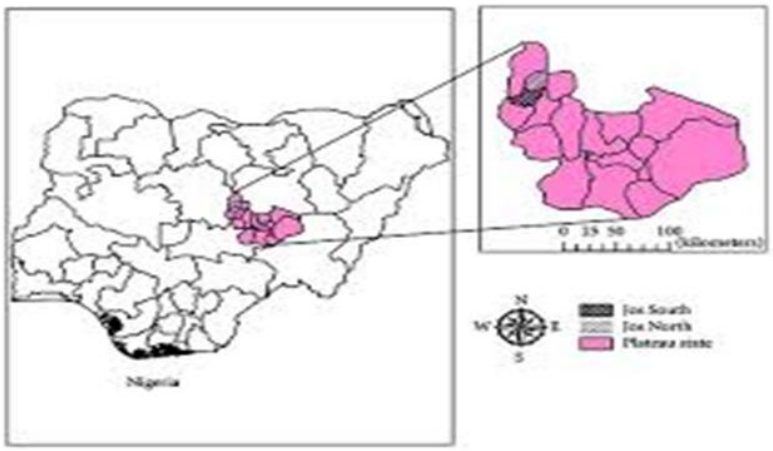


Figure 0.1: Picture Map of Jos, Plateau State, Nigeria

A Total of 40 questionnaires were administered, out of which 31 responses (77.5%) were received indicating. The Questionnaire was divided into two major parts; Section A consists of the characteristics of respondents involved in construction planning or scheduling, while section B consists of data used in scheduling of construction projects adopted for construction projects. Data on provisions made in preparing construction programmes were collected using structured questionnaires and past work programmes.

RESULTS AND DISCUSSION

Results of the data collection and analysis in the study are presented in Tables and Charts with appropriate discussions under each sub-section. Table 4.1 presents biodata of respondents while Table 4.2 shows their consideration in construction programme preparation.

Respondents Biography

Results of Table 4.1, shows that 93.5% of the respondents are Builders while only 6.5% are Civil/Structural Engineers. The results also shows that majority of respondents had Master's Degree as their highest educational qualification with 61.2%, 22.6% were B.Sc. holders, 9.7% holds PhD while 6.5% are HND holders. 67.7% of the respondents are involved strictly in contracting works, 19.4% does both contracting and consulting while those involved in consulting alone are 12.9%. 54.7% of respondents possess 6-10 years working experience, 19.4% had 11-15 years, and 9.7% had above 20years while 6.5% had 16 - 20 years' experience. All the respondents are experienced with construction work programming with varied years of involvement as reflected on Table 4.1.

Table 0.1: Respondents Characteristics

Characteristics	Parameters	Value	%
Area of Specialisation	Builders	29	93.5
	Civil/ Struct. Engrs.	2	6.5
Highest Educational Qualification	PhD	3	9.7
	M.Sc.	19	61.2
	B.Sc.	7	22.6
	HND	2	6.5
Nature of Business	Contracting	21	67.7
	Consulting	4	12.9
	Contracting & Consulting	6	19.4
	Specialized services	-	-
Respondent Experience in years	1 – 5	3	9.7
	6 – 10	17	54.7
	11 – 15	6	19.4
	16 – 20	2	6.5
	20 – Above	3	9.7
Respondents Experience in Construction Work Programming	1 – 5	4	12.9
	6 – 10	10	32.2
	11 – 15	13	41.9
	16 – 20	2	6.5
	20 – Above	2	6.5
Total		**31**	**100**

Source: *Field survey, 2016*

Table 0.2: Programme Planning Considerations

Characteristics	Parameters	Value	%
Time Provisions made in construction for rain days	0 – 7	2	6.5
	8 – 14	10	32.2
	15 – 21	12	38.6
	22 – 28	3	9.7
	29 – 35	2	6.5
	36 - 42	2	6.5
Peak rain Months	June	-	-
	July	7	22.6
	August	22	70.9
	September	2	6.5
Frequency of Construction Programme review	Once	3	9.7
	Twice	6	19.4
	Thrice	18	58
	Four times	4	12.9
	>Four times	-	-
Total		**31**	**100**

Source: *Field survey, 2016*

Provisions made in Construction programmes for Rain days

Results of Table 4.2 show that 38.6 % of respondents involved in preparing construction work programming adopted 15-21 working days /annum as provisions made for delays caused by rains; 32.2 % indicated 8-14 working days/annum; 9.7% made allowance of 22-28 working days/annum, while 6.5% each allowed 0-7; 29-35; and 36-42 working days/annum respectively, for delays caused by rains in construction work programming.

The results in Tables 4.2 also show that 70.9% of respondents involved in construction work programming in Jos indicated August as the peak month in the year for major delays in construction work because of heavy precipitation. 22.6% indicated July as the peak month for the rains while 6.5% indicated September as the month to observe for peak rains in the year. Table 4.2 further revealed that 58% of respondents involved in Construction work programming had reasons to review their work programmes three times in the course of a project, 19.4% had two reviews, 12.9% had the programme reviewed four times, while 9.7% had only one review. These results revealed that all the Professionals involved in construction work programming have spent additional hours revisiting and reviewing the original work programmes. This could be as a result of inaccurate provision made in the first place.

Comparative Analysis of Rainfall Pattern in Jos

Table 4.2 revealed that majority of the respondents involved in scheduling of building projects adopted 15 - 21 days/annum as provisions for delays in construction works in their construction programmes; this is by far six times below the average records of raining days (112 days/annum) as shown in Table 4.3.

Table 0.3: Rainfall patterns (i.e. Raining days/Month) for Jos Metropolis for (2005 - 2015)

Month/Yr.	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	**2015**	**Sum**	**Mean**
January	0	0	0	0	0	0	0	0	1	0	0	0	0
February	0	3	0	0	0	0	1	0	0	1	2	7	1
March	0	4	1	1	0	4	0	0	2	2	2	16	1
April	5	8	10	6	10	7	4	10	9	13	1	83	8
May	11	18	14	16	9	18	11	15	9	18	16	155	14
June	18	15	20	15	16	17	16	15	16	15	15	178	16
July	26	21	22	25	20	20	21	21	18	22	19	235	21
August	24	23	27	26	25	23	23	22	20	20	26	259	24
September	20	21	12	17	16	20	12	20	18	22	16	194	18
October	6	7	2	7	15	12	9	6	8	6	3	81	7
November	0	0	0	0	2	0	0	0	0	0	0	2	0
December	0	0	0	4	0	0	0	0	1	0	0	5	1
Total days	**110**	**120**	**108**	**117**	**113**	**121**	**97**	**109**	**101**	**119**	**100**	**1215**	**112**

Source: Nigerian Meteorological Agency; station point located at Airport Heipang in Jos 2016.

This goes ahead to support evidences shown in Table 4.2 that majority of the construction programmes prepared by respondents have been inaccurate and resulted in repeated reviews (i.e. twice or three times) during the construction phase of a project. The use of inaccurate data in practice can be argued as the cause of time overrun in construction project delivery. The results further revealed that respondents indicated August as the month with the highest frequency of occurrence of rain; this is confirmed with an average of 24 days of rainfall/month and hence adjudged the peak months annually. Results presented on Table 4.4 also confirmed that the Month of August had higher rainfall volumes been the peak month in six (2006 (25%), 2008 (24%), 2009 (25%), 2010 (24%), 2011 (24%) & 2015 (27%)) of the 11years studied with an overall average minimum volume of about 25%. The month of June was peak in two years (2005 (26%) and (2007 (23%)); July was peak in 2013 (30%) while May was peak in 2012 with 29% volume of rainfall for the year.

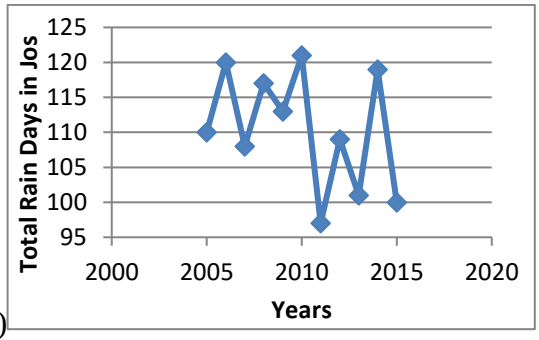
Table 0.4: Rainfall Amounts in mm for Jos for the period of (2005 -2015)

Mth/Yr	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	**2015**
Jan	0.0 (0.0)	0.0 (0.0)	0.0 (0.0)	0.0 (0.0)	0.0 (0.0)	0.0 (0.0)	0.0 (0.0)	0.0 (0.0)	4.5 (0.4)	0.0 (0.0)	0.0 (0.0)
Feb	0.0 (0.0)	35.5 (2.8)	0.0 (0.0)	0.0 (0.0)	0.0 (0.0)	0.0 (0.0)	7.4 (0.6)	0.0 (0.0)	0.0 (0.0)	4.8 (0.4)	37.6 (3.1)
Mar.	0.0 (0.0)	1.5 (0.1)	11.1 (0.8)	0.3 (0.02)	0.0 (0.0)	48.4 (3.4)	0.0 (0.0)	0.0 (0.0)	1.0 (0.1)	6.6 (0.5)	20.3 (1.7)
April	92.5 (7.7)	51 (4.1)	82.5 (6.1)	69.2 (5.3)	87.6 (7.4)	76.6 (5.3)	45.9 (3.9)	66.6 (4.5)	166.6 (14.9)	242.7 (19.6)	8.8 (0.7)
May	124.6 (10.3)	222.9 (17.7)	176.6 (13.0)	224 (17.2)	135.8 (11.4)	142.1 (9.9)	193.9 (16.4)	315.4 (21.5)	95.5 (8.5)	140.3 (11.3)	136.9 (11.3)
June	310.6 (25.7)	146.6 (11.7)	310 (22.9)	117.1 (8.98)	100.4 (8.5)	218.1 (15.2)	170.5 (14.4)	240.3 (16.4)	172.1 (15.4)	191.4 (15.4)	185.5 (15.3)
July	223.8 (18.5)	178.2 (14.2)	303.5 (22.4)	272.7 (20.9)	167.8 (14.1)	245.3 (17.1)	240.2 (20.3)	429.0 (29.2)	333.8 (29.8)	248.8 (20.0)	264.7 (21.8)
Aug.	263.4 (21.8)	307.9 (24.5)	286 (21.1)	307.6 (23.9)	299.4 (25.2)	345.4 (24.1)	281.4 (23.8)	156.9 (10.7)	161.0 (14.4)	139.0 (11.2)	332.1 (27.4)
Sept.	138.1 (11.4)	245.6 (19.5)	184.1 (13.6)	195.2 (15.0)	190.3 (16.0)	263.5 (18.4)	170.2 (14.4)	201.2 (13.7)	104.2 (9.3)	191.2 (15.4)	205.2 (16.9)
Oct.	55.9 (4.6)	67.9 (5.4)	1.8 (0.1)	93.6 (7.2)	176 (14.8)	93.2 (6.5)	75.3 (6.4)	58.6 (4.0)	70.7 (6.3)	76.5 (6.2)	23.0 (1.9)
Nov.	0.0 (0.0)	0.0 (0.0)	0.0 (0.0)	0.0 (0.0)	30.4 (2.6)	0.0 (0.0)	0.0 (0.0)	0.0 (0.0)	0.0 (0.0)	0.0 (0.0)	0.0 (0.0)
Dec.	0 .0 (0.0)	0.0 (0.0)	0.0 (0.0)	24.7 (1.9)	0.0 (0.0)	0.0 (0.0)	0.0 (0.0)	0.0 (0.0)	9.8 (0.9)	0.0 (0.0)	0.0 (0.0)

Values in parenthesis (*) refers to the percentage of the monthly rain amount for the specific year.
Source: Nigerian Meteorological Agency; station point located at Airport Heipang Jos 2016.

Figures 4.1 a and b further revealed the variations in climate over the 11 years period and the fact that even though the month of August experienced the peak of rains, it is not a rule of the thumb as the Month with peak rainfall for all year round.

The records showed that the Months of July and August have the highest percentage of rain volume in the 11 year period and therefore are not suitable for major outdoor construction works or activities, this was largely confirmed by respondents involved in construction planning or scheduling from Table 4.2.

(a) 

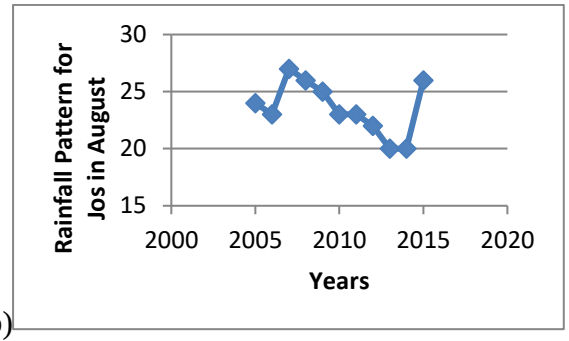
(b) 

Figure 0.1: Graphical Representation of Rainfall Pattern in Jos (a) the Rainfall variations for 2005 – 2015;

(b) Rainfall Pattern in August

Figure 4.2 confirms the fact that the months of August and July experience at least 20 working days of rain each on the average. These raining days are not suitable for carrying out major or critical outdoor construction activities such as concreting, excavation works and landscaping. It is important for Builders and Construction Managers involved in construction scheduling to be observant and stay updated with the current trends in the weather and climate change.

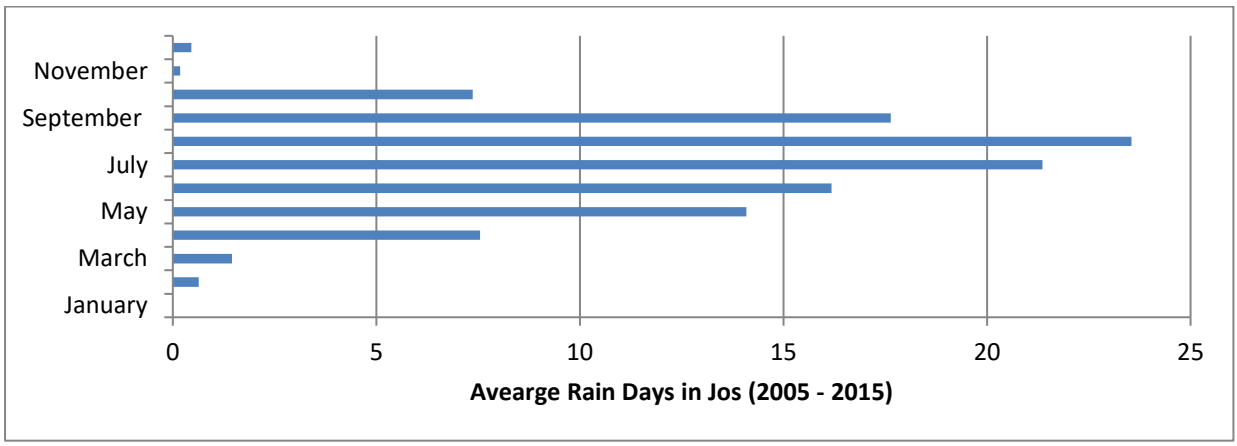


Figure 0.2: Bar Chart Indicating the Average Rain days in Jos for the period (2005 – 2015)

CONCLUSIONS AND RECOMMENDATIONS

The frequency at which work programmes are being reviewed determines the length of the time spent on a construction project and hence the time overrun. It is no doubt that the longer a Contractor stays on a construction site, the more the amount spent in running the site i.e. cost overrun. It follows that making work programmes with inaccurate data will indirectly affect the time and cost of a construction project. This study therefore emphasises the need for Builders and Construction Managers to work with reliable data in construction planning and make effort to update their knowledge of weather conditions as climate is not a constant phenomenon. Construction work involves selection of building materials, purchase, transportation, warehousing or storage, on site or offsite fabrication and lastly the installation

or erection of elements and components. This process requires inputs of various participants in the construction supply chain. It is therefore imperative for Builders and Construction Managers to not only plan work schedules that are reliable for them; but take a holistic consideration of others Stakeholders in the supply chain for an effective delivery of building and construction projects.

REFERENCES

Alinaitwe, H. M., Mwakali, J. A. & Hansson, B. (2007), "Factors affecting the productivity of building craftsmen-studies of Uganda", *Journal of Civil Engineering and Management*, 13, pp. 169-176.

American Meteorological Society (2009), "Precipitation- Glossary of Meteorology", Retrieved 2016-06-02.

Arditi, D. (1985), "Construction productivity improvement", *Journal of the Construction Engineering and Management,* ASCE, 111:1-14.

Ayoade ,J. O. (1983), Introduction to climatology for the tropics, John Wiley and Sons.

Baldwin J. R., Manthei, J. M., Rothbart, H. & Harris, R. B. (1971), "Causes of Delay in the Construction Industry", *Journal of Construction Division*, 2, pp.177-87.

Bello, W.A., Adekunle, R.A. & Ogunsanmi, O.E. (2012), "Effect of climate change on construction project planning in Nigeria", In: Laryea, S., Agyepong, S.A., Leiringer, R. and Hughes, W. (Eds) *Procs 4th West Africa Built Environment Research (WABER) Conference*, 24-26 July, Abuja, Nigeria, 399-411.

Benjamin, N.B.H., & Greenwald, T.W. (1973), "Simulating effects of weather on construction", *Journal of the Construction Division*, 99 (CO1): pp. 175–190.

Binbol, N. L. (2007), Chapter 4, Climate, In: Akwa V. L. *et al*., (Eds) ,Geographical Perspective on Nassarawa State Department of Geography, Nassarawa State University, Keffi, Onaivi Printing & Pub. Co. Ltd.

Carbon Disclosure Project – CDP (2010), Carbon Disclosure Project CDP 2010 Information Request, retrieved 2016-06-01. http://www.lendlease.com/en/Group/Lend-Lease/Worldwide/Responsibility/media/53D9956754124B82AE2C259CCB6D7B40.ashx.

Clayton, R. (1989), "Planning is the key", *Building Today - the official magazine of Registered Master Builders Association (RMBA)*, Auckland, New Zealand, 197, pp. 31-33.

El-Sayed, E. A. (2011), "Generation of Rainfall Intensity Duration Frequency Curves For Ungauged Sites", *Nile Basin Water Science & Engineering Journal*, 4(1), pp. 112-124.

Ewona, I. O., Osang, J. E., & Udo, S. O, (2014), "Trend Analyses of Rainfall Patterns in Nigeria using Regression Parameters", *International Journal of Technological Enhancements and Emerging Engineering Research*, 2(5).

Harold, K. (2003), Project Management: A Systems Approach to Planning, Scheduling, and Controlling (8th Ed.), Blackwell Publishing.

Pachauri, R.K. & Reisinger, A. (Eds.) (2007), Intergovernmental Panel on Climate Change - IPCC Fourth Assessment Report: Climate Change, IPCC, Geneva, Switzerland, pp. 104.

Koehn, E. & Brown, G. (1985), "Climatic effects on construction", *Journal of Construction Engineering and Management*, ASCE, 111(2): 129–137. doi:10.1061/(ASCE)0733-9364(1985)111:2(129).

Laufer, A. & Cohenca, D. (1990), "Factors Affecting construction planning outcomes", *Journal of Construction Engineering and Management*, ASCE, 116(1), pp. 135-156

Makulsawaudom, A. and Emsley, M. W. (2001), "Factors affecting the productivity of the Construction Industry in Thailand: The project managers' perception", *ARCOM Seventeenth Annual Conference held in University of Salford*, 5th – 7th September, Vol.1, pp. 281-290.

Moselhi, O., Gong, D., and El-Rayes, K. (1997), "Estimating weather impact on the duration of construction activities", *Canadian Journal of Civil Engineering*, 24(3), pp. 359–366 doi:10.1139/l96-122.

National Oceanic and Atmospheric Administration – NOAA (2010), "Sectoral Engagement Fact Sheet", NOAA National Climatic Data Center (NCDC), US Department of Commerce, retrieved 2016-12-02. http://www.ncdc.noaa.gov/oa/userengagement/construction.pdf.

Scott S. (2015). "What's the difference between 'rain' and showers'?", KOMO-TV, Dec. 26, retrieved 2016-06-31.

Thomas, H.R., & Yiakoumis, I. (1987), “Factor model of construction productivity”, *Journal of Construction Engineering and Managemen*t, ASCE, 113(4): pp. 623–639. doi:10.1061/(ASCE)0733-9364(1987)113:4(623).