Vegetation Related Subsidence of Low Rise Buildings

An analysis of the soil, climate and plant interaction as this relates to claim numbers 1975 – 2011
A paper presented to The Aston University, School of Engineering & Applied Science
20th June 2012

Michael Lawson*

Abstract

The dynamic relationships between low-rise buildings, cohesive soils, vegetation and climate are now well understood **(1,2,3,4,5,6,7)**. It is well established that the loss of water from the soil matrix to vegetation leads to changes in overall volume of the soil, which in the presence of a loaded low-rise structure can lead to a differential downward / rotational "subsidence" exacerbated by the overall brittleness of modern buildings. This water loss is driven by plant requirements, which are principally a function of seasonal transpirational demand, which is equally of a higher magnitude during warmer and drier summers.

This paper now extends the earlier theoretical model developed by OCA UK Ltd for interpreting and analysing the historical context of changing weather patterns over longer timescales. From this it is anticipated that better claims profile forecasting may be possible for the insurance industry, central and local government. The principle tools utilised in the analysis are the Meteorological Office Rainfall and Evapotranspirational Calculating System (MORECS) 1975 - 2012. **(8)** and the claims record of insurers during the period 1992 - 2011. **(10)**.

Introduction

The development of the MORECS system from an agricultural management tool to multi-purpose land management and subsidence claims handling system has taken place against the context of rapidly rising subsidence claims since the 1970s. Throughout the 1990s the Meteorological Office and certain system users have researched and developed the MORECS model to more effectively interface with the real time problems of building failure. **(11)**.

However whilst the overall flow of MORECS data now spans many decades there is currently no single theory that describes the data in its full sense. This paper cannot hope to complete this task, however it is hoped that it will allow a basic model to be developed from which a comprehensive theory of "how claims occur" might be established.

The attached graphical representation of the MORECS data is for a single Grid Square representing a 40km square territory centered north of the river Thames and north London. The data is extrapolated from the deciduous trees profile data and plots weekly MORECS measurements.

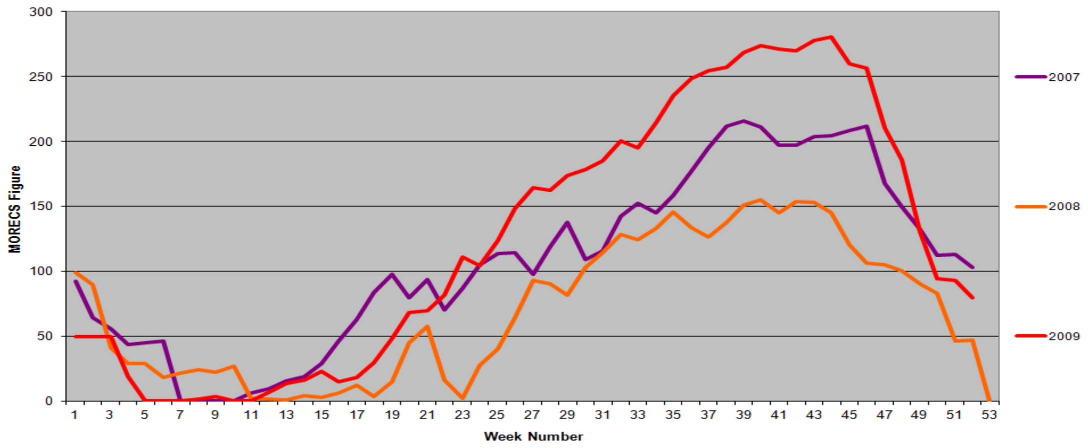
This particular Grid Square (161) is underlain by a highly cohesive London Clay which shows classical geotechnical properties of very high plasticity, high shrinking and swelling properties in the presence of vegetation and a poor rehydration profile following precipitation. It therefore drives a relatively "clean" picture of vegetation resource depletion of soil water and of root architecture across all plant species.

The meteorological picture is equally relatively settled with a fairly predictable annual rainfall total that need only move in modest percentage terms from year to year to produce clear trends.

The picture that emerges from the analysis is of two very pronounced and quite different soil – plant - atmospheric "states" of the overall phase space from which the system "flips" periodically to the opposite state.

The full MORECS data set covers a period from the beginning of policy inception of cover for subsidence of low rise buildings during the 1970s to the present day and therefore is a very accurate and well established model. However for the purposes of this analysis a detailed assessment has been carried out which sets the ordinary meteorological "phase" for the UK against the less typical hot/dry phase of "event years".

Fig 1 (MORECS data – wet phase)



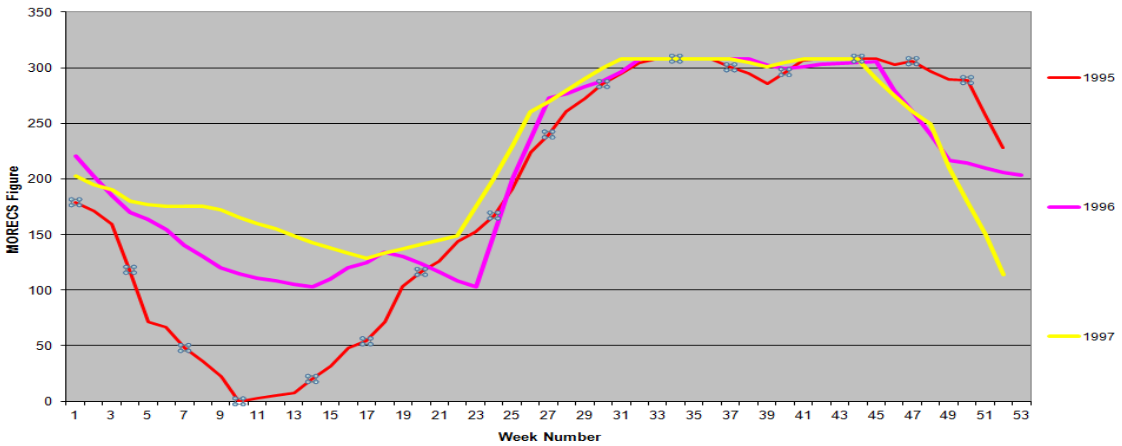
The wet phase (note "wet" is a descriptive term designed to simply assert it was not a noticeably dry year)

Within a typical wet phase (i.e. 1998 - 2002) total precipitation and available soil water in the agricultural soil is sufficient annually to satisfy most plant growth with claim numbers relatively low, the repudiations against those claims (being that insurers representatives do not believe the cause is soil differential movement) relatively high and the vegetation related claims not being repudiated are associated with trees which are very close to properties, large and growing rapidly, large and with a very high moisture requirement adjacent highly susceptible buildings, contributory to some other cause (e.g. drainage problems) or associated with a policyholder or prospective policyholders intolerance of any building movements (i.e. new homebuyers).

The dry phase (note "dry" simply indicates a movement towards higher soil moisture deficits)

In the dry phase (1995 - 1997) total precipitation has been below average at some critical period (e.g. low winter rain) or for an extended period and is characterised by an initiating event year of hot and dry summer temperatures putting plant communities under real and prolonged water stress.

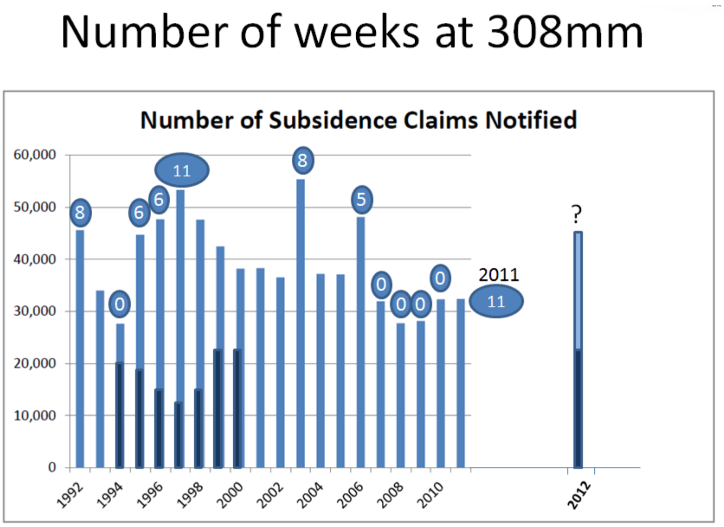
Fig 2 (MORECS data – dry phase)



An event year

Event years are a soil – climate – vegetation - insurance reality. Within the model, event (or *Alpha*) years are characterised by a warm / hot and/or extended dry summer / autumn period of between 10 and 20 weeks duration. This period is the initiating event, which leads to high evapotranspirational levels and a rapid rise in MORECS figures between May and September of that year. To be an event year the MORECS figures will achieve "model" exhaustion of the first 1m of model soil and a period of time will elapse (October – December) when the peak value is maintained against the gravitational force of precipitation by evapotranspirational activity of plants. The peak is reached and sustained against autumn rains.

Fig 3



The plant response

The model postulated suggests that fundamental changes occur as a result of this initiating event in the root architecture of clay specialist vegetation and clay opportunist vegetation. Root architecture for many tree species is flexible with high levels of plasticity in root form and function when subjected to drought conditions. **(9).**

As a result of the initiating event it is proposed that for many common plant species growing within the United Kingdom this plasticity whilst designed to invest the engineering soil "Resource Depletion Zones" (RDZs) has a second important outcome.

The *Beta* & *Gamma* years

There is no doubt that the *Alpha* year exists as a phenomena which initiates a dry phase and that one can postulate factors that would lead to a higher claims total in the second year after the initiating event that are not technically related to geotechnical / arboricultural factors, (i.e. greater public awareness, lower repudiations by sub contracted specialists less familiar with the issues as a resource requirement of insurers). However to ignore the plant response is felt to be potentially damaging to our understanding of this issue.

One reality of an initiating event is that roots of plants are now "in-situ" within the engineering soil RDZ at depth. The very high MORECS "account" being at the maximum modelled and only slowly declining into the winter and following spring inevitably means that a "positive" MORECS figure elevates plant soil water requirements and the building deficit against the ordinary fully saturated soil model of a wet phase spring. The plants will require water many weeks earlier from available root architecture already fully invested and ready to "work" at transpirational requirements.

The model therefore proposes a "trajectory" for the *Beta* year as a result of the *Alpha* that is inevitable. This is regardless of the weather associated with the *Beta* year, although it is possible for hot dry weather in the *Beta* year to further extend the event duration. The current proposition is that this trajectory can in certain circumstances extend so far as a Gamma year regardless of the current climatological position and simply as a function of the energy applied in the Alpha year and the long-term cybernetic response from many clay specialist tree species and opportunist trees.

Beta & *Gamma* Years – analysis

An assessment of the key-initiating *Alpha* years; 1976, 1990, 1995, indicates all of the factors and trends earlier referenced, what is clear against these trends is that the elevated MORECS figures in the following springs produced meteorological and geotechnical *Beta* years. For the first 3 events the "flip" to the new state was sudden and achieved in a matter of weeks whilst the return to the wet phase was slow and achieved over many months. The model suggests that an initiating event will guarantee a minimum of 12 months of elevated claims numbers with lower repudiation rates with the possibility of a 20 month+ dry phase affected and directed by the *Alpha* year impact on soil / vegetation continuum, almost regardless of the precipitation rates in the *Beta* year. In this regard 2003 is of interest as a short sharp autumnal event very much within the context of what was actually a relatively wet phase and unlike the years 1975-1977, 1989 – 1991 and 1995 – 1997.

The 2003 Alpha year

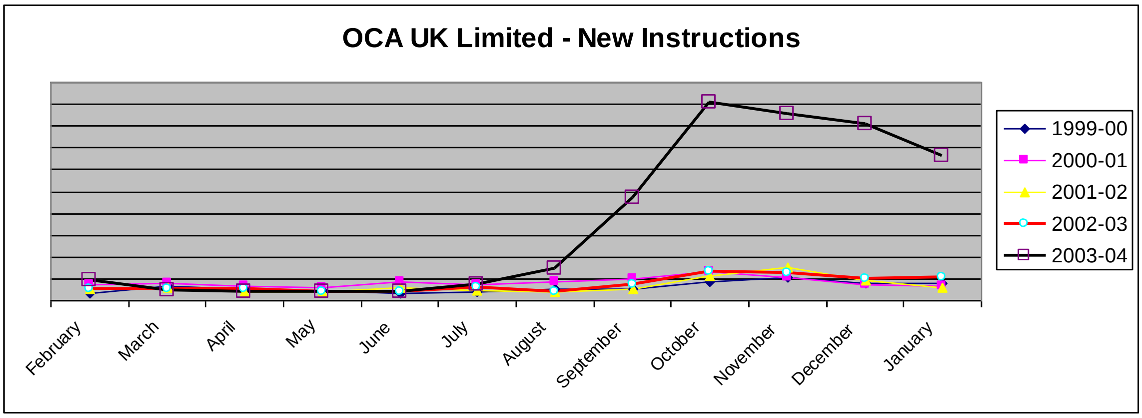
The 2003 event follows a predicted pattern as an initiating year only weakly with MORECS figures growing towards the figure of 300 mm deficit against a highly variable weather pattern with wild swings in anomaly against the long-term average.

The claims experience – OCA UK Limited

By July 2003 it was clear that a sudden major dry weather event was in progress and OCA UK Limited in line with the agreed insurers surge plan of operations authorised its own response both financially and operationally as of 1st August 2003. This surge plan assumed a sudden and sustained rise in claim numbers with low repudiations and high numbers of tree related claims moving across the UK but focussed on the south and east, (a continental effect).

Fig 4

Increase in claim numbers against base.



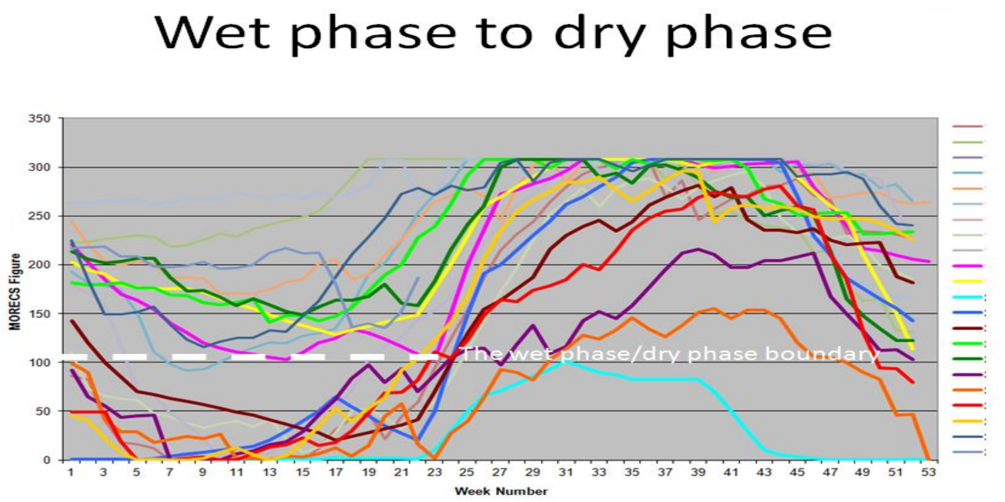
It should however be obvious that the claim experience confirms an initiating role of the Alpha year model in plant response to a dry weather event which was particularly pronounced in the final 4 months of 2003.

Analogue years and "Super Events"

We can now extend the above concept of the Alpha – Beta model of significant events years to the principle of the analogue year.

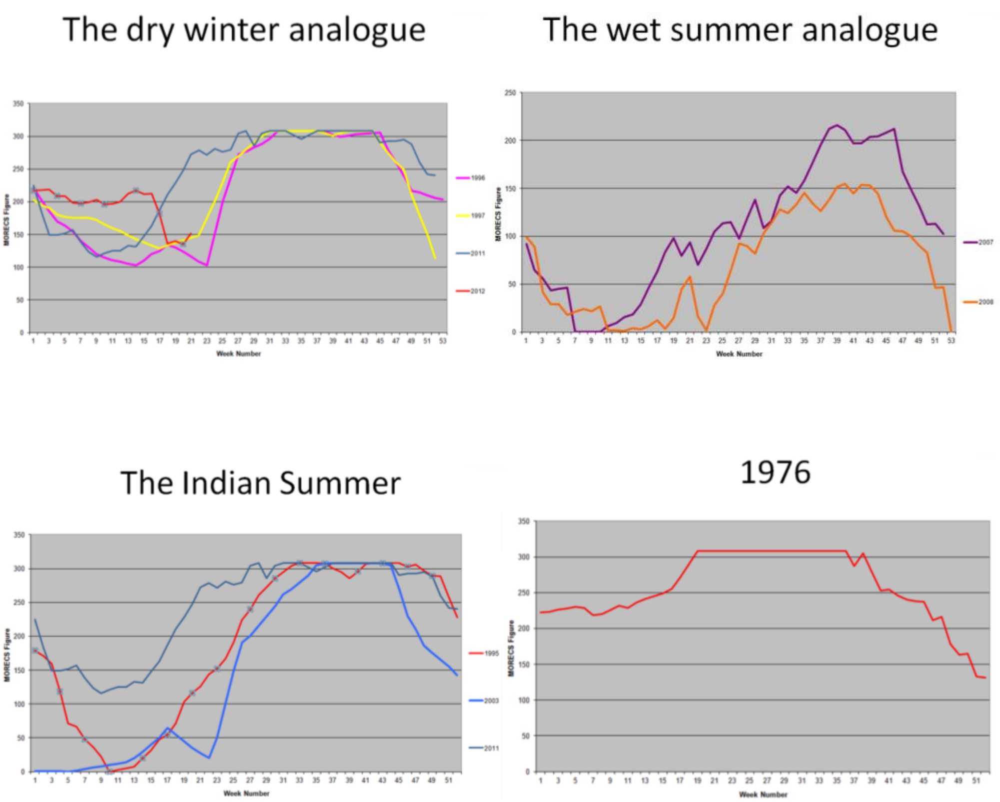
It is quite clear that there are a range of analogue types with consistent profiles that can be tracked.

Fig 5



There is a clear case for establishing these analogue years as the basis for further research.

Fig 6



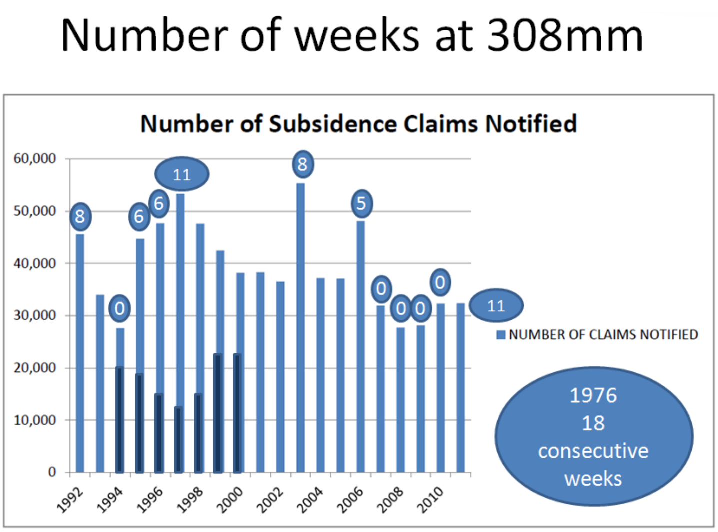
The Super Event

Insurers should also be aware that "super events" with a low statistical probability but potentially devastating impact exist in the data.

All other dry phase event periods had a maximum 308mm MORECS figure for Square 161 over relatively modest consecutive weeks even if the combined total was higher over the whole summer (2011, 1997).

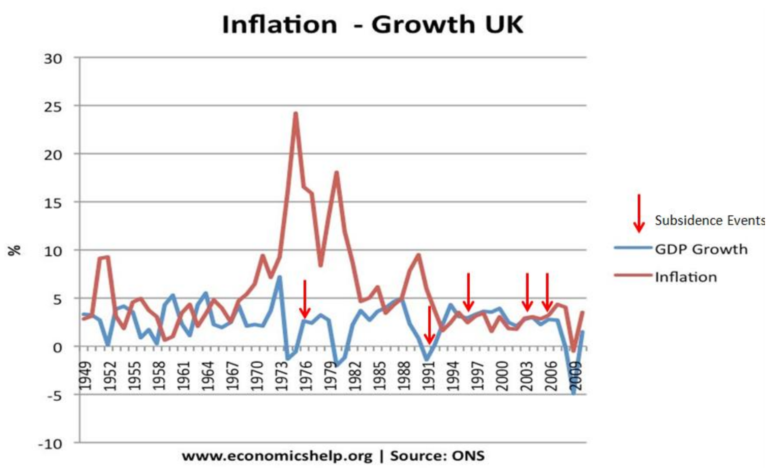
The year 1976 had a quite unique 18 consecutive weeks maximum MORECS between the start of May and start of September 1976. This level of persistent MORECS if applied to the modern market would have likely devastating impacts on the claims handling capacity of the sector.

Fig 7



If an event of this magnitude hits an industry that has streamlined significantly since 2008 then the capacity of the sector will be severely strained. If this event coincided with a period of economic growth then the total number of claims would reach levels never previously seen.

Fig 8



Conclusions

It is hoped that this introductory paper may allow forward planners to better understand the potential for changes occurring to the "state" of soils, such that decision making can be informed and effective. The dry phase clearly has affected approximately 4 of every 10 years since the 1970s although the traditional paradigm is to locate events by the initiating event year i.e.1976, 1995, 1991, 2003. We would suggest this approach is simplistic and that it would be better to analyse dry periods as a continuum beginning with the Alpha Event.

Clearly the ability of insurers to overlay this model against claims experience, particularly with access to the statistical data available to the authors covering substantially more than 30,000 tree-related subsidence cases, would prove invaluable to strengthen the models scientific base.

Equally there are issues that require investigation associated with any extension of an event beyond the Gamma year and the impact on soils and tree strategies and survival in any extended event of that severity.

We would hypothesise that the current wider climate models predicting as they do overall elevated temperatures against a background of sudden sharp changes in the "state" of the weather over increasingly short periods, will only potentially exaggerate the magnitude and duration of the *Alpha – Gamma* phase state. It is the author's contention that the overall model is robust and capable of testing and further refinement.

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Michael Lawson is Chief Executive and Managing Director of the Landscape Planning Group Limited which includes OCA UK Ltd. He has been working on tree related clay shrinkage cases for the last 20 years.

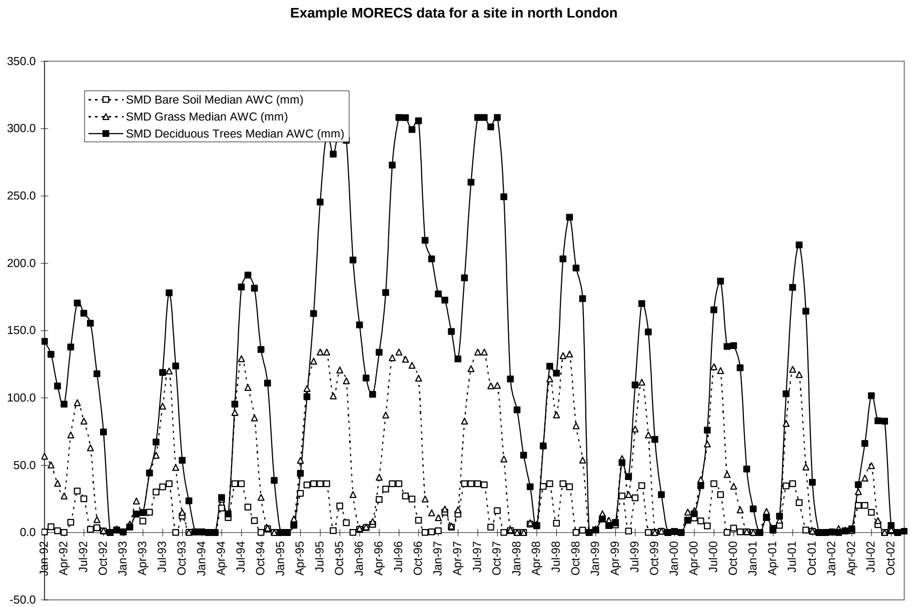

CHART 1
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