DOES AGAVE HAVE FUTURE AS A BUILDING MATERIAL IN NEW ZEALAND?

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ABSTRACT

Agave Americana is a species of the family of plants *Agavaceae*. This species is native to North America, with its centre of origin being in present-day Mexico. Agaves are naturally found from the south western United States through Central America, the Caribbean, and into northern South America. At a later stage, following European contact, the agave plant has been spread around the world, and is today found as an introduced plant that has successfully adapted to some regions and environments in New Zealand. When talking about natural building materials with a sustainable focus, many species of wood and bamboo have been well studied and have a long history, yet agave as such a material is seldom mentioned although it has a background history of many possible uses. The purpose of this paper is to further consider whether or not agave has potential applications in New Zealand as a sustainable building material.

Particular interest is paid to the vernacular application of this plant as a building material in the history of certain cultures of Mexico such as the Otomi or Mixteca. Evidence in early documents, ethnographical records and archaeological material shows many uses since the beginning of civilizations in Mesoamerica up to more recent findings. A field study on the plant is described in the paper. The focus here is to emphasize those crafts and skills associated with this plant in order to give general comprehension of its wide range of applications. For example it has been a staple food and widely used as a beverage, It has also been used for restoring soils and controlling erosion, for weaving and rope making, and for fencing as well as for making houses. In this paper special attention is given to the use of the plant as a building material, and making use of as much of the plant as possible, thereby minimizing waste.

The paper will discuss further studies that could be applied to the existing research on agave and will outline a number of tests that can be made following specific methodologies. The aim is to provide guidelines for the useful values of its various features (structural, technological, environmental and ecological) related to improvement and potential development of innovative products of the agave and their sustainable applications in the area of natural building materials.

KEYWORDS:

Agave; Maguey; Vernacular; Natural Building Material; Sustainable.

INTRODUCTION TO THE AGAVE FAMILY

In most botanical works the genus Agave is classed as a member of the Amaryllidaceae. However, certain characteristics led English botanist, J. Hutchinson, to establish a special family, that of the Agavaceae, in which he also included *Phormium tenax*, the New Zealand flax or hemp. (Critchfield, H.J. 1951)

All species of agaves have some common characteristics. The fleshy, longish or lanceolate leaves end in a sharp point and usually bear spines on their margins. They form a rosette which for the first few years rests on the ground. Over many years new leaves are regularly formed which are arranged in a spiral. In sisal (*Agave sisalana*) the leaves may attain lengths of from two to five feet. With progressing age and with the consecutive formation of a stem, the lower leaves begin to die off unless, as in cultivated plants, they are previously cut away. Older specimens thus bear their leaf-rosette at the top of a stem of varying height (Bally and Tobler, 1955) p. 378.

Young leaves assume first a vertical, but in course of time a more or less horizontal position. During its lifetime a sisal plant, -one of the most fibrous species among the Agavacea family-produces an average of 300 leaves, a fairly constant number, varying little under the influence of environmental factors. On the other hand, the length of the leaves is strongly influenced by soil and climate, and this is of great importance for those using the plant. (Drennan, P. M. and Nobel P. S. 1996; Pimienta-Barrios, E. and Robles-Murguia, C. 2001; Arizaga, S. and Ezcurra, E. 2002)

The genus *Agave* comprises 250 to 300 species. In 1933 H. Ross established no less than 62 species for Mexico alone, most of which are used for fibre production but only in very restricted areas. (Bally and Tobler, 1955) p. 380.*Agave Americana* (see figure 1) is the species commonly known in the central Mexican highlands as 'Maguey', a plant well known through all Mexico and of many uses from drink to food, to fibres for roping, making shoes, weaving and parts of the plant can be used as building elements. It is also the agave plant found with successful adaptation in New Zealand (see image 2).

Another useful type is *Agave sisalana* Perrine, the true or white sisal. Able to form a stem, sisal gives rise to many suckers, and possesses coarse fleshy leaves of green or bluish-green hue, with very few, if any, spines on the margins. The term "sisal" recalls the port of the same name in Yucatan from which the first sisal fibres were exported. In 1836 the American Perrine took sisal to Florida, from where it was transplanted to Africa and Indonesia (Bally and Tobler, 1955) p. 380.

In western Mexico fibres are also derived from the Mezcal agaves (*A. tequilana* Weber, A. *pseudotequilana* Trel., *A. palmnaris* Trel., and *A. pes-mulae* Trel.) commonly known as 'agave azul' are used for brewing and distilling tequila liquor, a favourite local drink. Like tequila made from this agave azul, this drink classification belongs to the compound of drinks of 'Mezcales' a term designating liquor resulting from the distillation of agave type plants. The distilling process in Mexico was known as an introduced technique via the Pacific, the Philippine-type still (Hough 1900; Bruman, 1944; Bruman 1945; Bahre, 1980) being different to the traditional process of brewing pulque.

Of the cultivated plants in Mexico which caught the attention of the Spaniards soon after the Conquest, agaves were among the foremost. As early as 1528, Pater A Motolinia gave a description of them. According to Motolinia, the natives used agave fibres to make sewing thread, twine, cords, straps, harness and even clothes and shoes. The intact leaves served as roof covering and for building water pipes. (Bally and Tobler, 1955) p. 381.

These Maguey plants like the one specie *Agave Americana* have two principal products of processes: fibres from the leaves and potable sap (fresh or fermented into the brewed drink 'pulque') but the plant also can produce medicine, construction materials, fuel and many other products (Parson and

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Parson 1990). It has been subject to research in diverse areas but not in the building related areas apart from as aggregates for cement. In the field of archaeology and ethnography in Parson and Parson is summarized the instrumental role played by maguey in the agrarian development in the highlands of Mexico in the Formative period, relating to the set of tools revealed from archaeological research as maguey processing equipment linking technological changes in the design of these tools with changing patterns of cultural adaptation.



Figure 1: AGAVE AMERICANA, METL, MAGUEY PLANT, Image taken in Cholula Puebla, Mexico showing the transversal section of the fibrous leaf. Photo J. Rios



Figure 2: AGAVE AMERICANA WITH FLOWERING STEM, Specimen recorded in Napier, New Zealand on April 2009. Photo J. Rios

Agaves have been used for many purposes for hundreds of years. It has been suggested that agaves could be used in the manufacture of emulsions, pectins, toilet preparations, boiler compounds, vitamin C complex, glucosides and saponins, and as a precursor for cortisone (Krochmal et al. 1954) p.6. Moreover, several species of agaves *Agavaceae* are to-day exploited for hard fibres in many industries in North America for instance (*Agave Lechugilla* Torr.) palma samandoca (*Yucca carnerosanaI* (Trel.) McKelvey) the source of 'Ixtle' or 'istle' fibre used mostly in brush making (McLaughlin and Shuck, 1991) p.481.

Of all the agaves, sisal has attained the greatest importance as a cultivated plant for its fibre, and the fact that its leaves are devoid, or nearly devoid, of marginal spines proving one of numerous points in its favour. Strangely enough, sisal, though indigenous to almost rainless Yucatan and in habit a typical xerophyte adapted to a dry climate, also grows well in regions with considerable precipitation and even produces a greater amount of fibre (Bally and Tobler 1975) p.382.

AGAVE TRADITIONS AND SKILLS IN THE HIGHLANDS MEXICO

Since remote times all around Mesoamerica agave plants have been related to many myths and rites.

The plant is found in many diverse representations of the Mesoamerican Pantheon (see figure 3). Mayahuel being the version related directly to the Agave plant.. The maguey because of its properties was related with the sacred, precisely because the maguey plants retain a lot of water in their roots from the underground supplies, and provide this precious liquid to people in a very inhospitable environment, although it can be easily grown in more tropical areas. The maguey plant, through migrations, was spread and broadly cultivated in the territory of the highlands and ranges ensuring not only liquid, but also food, both in the form of insects with the worms that are found in the plant, but also fromchewing boiled young stalks, 'quiote' Its leaves as mentioned have a very high content of fibrous material, and it has proven to be a good building and survival material (see parts of the agave in figure 4).

Figure 3: MAYAHUEL: NAHUA GODDESS OF MAGUEY image taken from Códice Fejérváry-Mayer (1994)



The Otomi indigenous people are said originally to have been a part of the Chichimeca people who migrated into México. Historians generally agree that originally the Otomi were a nomadic people whose name comes from the Nahuatl word Otomitl, meaning wanderer. Long before the coming of the white man this group of the Otomi were forced by threat of conquest into the arid and unfertile Mezquital Valle, located in Hidalgo, Mexico,. (Lanks 1938) p.184.



In here agriculture was never properly developed, because of the arid nature of the place. They survived as hunters and seed collectors, in doing so, they discovered and developed the fibre of the *metl* or maguey. *Agave Americana* was recorded early, associated with 9000-year-old mummified human remains (Nobel 1994) p.28. The bulk product of the plant can be used and has been used in construction elements. For instance the flowering stalk has been used as post and beam for building shelters and the leaves to build walls and for roof tiles. *Agave Sisal* or henequen is famous for the very strong and high quality fibres used in ropes, and in the present as an aggregate for cement.

Figure 4: DIAGRAM OF *AGAVE AMERICANA*. Drawing by J. Rios



Figure 5: THE MANY USES OF THE PARTS OF THE AGAVACEAS Drawing by J. Rios

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From early times there exist some representations of houses made with diverse materials and designs that were used in pre Columbian ages. In these are found in ethnographic evidence of the many uses of agave plants. Moya Rubio defines *quiote* (Mexican-Spanish), from the Mexican *quiotl* (Nahuatl) stalk of about 5 to 7 metres, as that which is cut and cleaned with a machete and then, after it is dried, is used as beam or post.

In <u>Artes de Mexico</u>, number 51 page 36, dedicated to the Maguey, is found an Otomi building in which is expressed the following about the technique used. The original text is given with the translation below.

"When the leaves are pruned they are put in the sun to dry, about eight or ten days more or less. Then they turn flexible as leather and they do not break. After being split and cleaned of spines and edges, they are ready to interlace in the roof. One type is known as halves, the other as wholes. Halves are cut all along the middle edge, while, in the wholes just the chunky part is removed".¹



Figure 6: VERNACULAR HUT MADE OF MAGUEY, QUIOTE STRUCTURE, AND PENCA AS ROOF AND WALLS Image taken from "El Maguey." <u>Artes de Mexico</u>, no. 51, Photo: A. Estrada.

¹ Translation of the original text in Spanish by the author. "Cuando se van podando las pencas se ponen al sol para que sequen, unos ocho o diez días más o menos. Entonces se vuelven flexibles como el cuero y no se rompen. Después se cortan por el centro y se quitan las espinas y los bordes antes de entrelazarse el techo. Uno se conoce como mitades, y otro se llama entero, el de mitades se cortan las hojas por la línea central, todo el largo de la hoja, y esto da como resultado dos mitades, en el entero solo se cortan las partes gruesas de las hojas".



Apart from 'mezcal' liquors, today fibres are the most used researched and industrialized part of the agave plant. The crude traditional method for taking out the fibres, is generally undertaken by two persons. After the spines are removed, the pulp of the stalk is crushed by beating with a wooden club on a stone. Afterwards, the pulp and juice are separated from the fibres, and this is done by taking half the leaf and working with a crude iron scraper on a board. After the stalk is scraped as clean as possible, the loose fibre is washed in soap and water or in corn water. Finally, it is dried and tied into bundles, ready for the family to sell. With the case of the fibres extraction the process has been improved for its uses as cement aggregates, ropes, and other applications.

Figure 7: IXTLE FIBRES OF AGAVE BLANCO. Hidalgo, Mexico 1988, Photo: A. Estrada in Artes de Mexico issue 51 about "El Maguey"

Agave Americana or 'maguey' is one plant with great possibilities for developing new technologies based in ancestral technology and indigenous knowledge. The raw material of the plant can be studied for improving local peoples' quality of life through better housing and better building. Since is a strong fibrous material of high quantity it can potentially offer structural, thermal, acoustic and healthy materials for use in building. Although in the present day traditional skills and crafts are endangered by the modern shifting into an industrial development of more and more synthetic fibres, the maguey plant offers many products to work with in contemporary ways.

AGAVE AS A MATERIAL FOR MODERN BUILDINGS

Modern New Zealand is very different from the Highland Valleys of formative Mexico but agave grows successfully in New Zealand and could be considered a potential natural building material.

In order to consider the propagation and possible plantation of Agave for building purposes there are things to consider regarding the viability of massive planting. Agave, which grows without any special care, is excellent for avoiding erosion of the land unlike many tree plantations that greatly erode the soil during the process of planting and harvesting or because of deforestation. (Smith, A.P. and Young, T.P. 1987; Melville, E. G.K. 1990; Backeus, I., Rulangaranga, Z.K. and Skoglung, J. 1994; Garcia-Romero, A. 2001) It is also a plant that needs no special care due to its wild strong nature to grow and propagate by itself. The maguey cultivators in the Basin of Mexico as a land use strategy, built terraces with inter-planting of maguey and grain which formed the house garden of the villages (Susan T. Evans 1990:117 Maguey can be used for distilling 'mezcal' type of wine, as a nourishing beverage, as a fibrous material of many uses, or its many parts can be applied into areas related to the building industry, with potential application as posts and beams, ropes, aggregates for mortars, cements or earth mixes, landscape and erosion control.



Figure 8: AGAVE AMERICAN REORDED IN NAPIER EAST COAST NEW ZEALAND. Spread along the shoreline railway Agave Americana is found successfully adapted to New Zealand soil and environment. Map source: Kiwimaps, edition and Photography: J. Rios

Agave does not require special attention being a strong plant that grows naturally without any need for pruning or protection, although further research in the species of Agaves are necessary to investigate its values for its use as a construction material, as well as the time in which the Agave can be domesticated and plantations can be established and be made ready for harvesting. However, just as the modern use of other plants like bamboos or palms has shown, the way agave was used for diverse crafts and buildings in Mexico in the past may be very different from the way agave could be used for buildings in the modern world scenario either in Mexico, New Zealand or other places.

About its potential application as a building material, the stem of the agave forms a very long and strong pole that can be used in roof structures and walls (see Figure 9), much as timber is. The use of leaves as a cladding may not have a place in New Zealand building. Alternatively, the fibre of the agave could form a reinforcement for other materials, such as combining it with earth, in much the way straw or grasses reinforces cob or mud bricks, which has been used for building in New Zealand.



Figure 9: FLOWERING STALK OR 'QUIOTE' FROM A SPECIMEN IN NAPIER NEW ZEALAND. Material subject to be applied in further research about the structural and biological properties of the parts of the Agave plant as a building Material. Photo: J. Rios April 2009

CONCLUSION

There are two reasons for thinking about the Agave as a possible New Zealand building material. The first is that the ecological impact of 'natural materials', such as the Agave is much smaller than that of man-made materials such as steel or concrete or many other plastic derived materials and fibres applied to building products, even when these are recycled. Therefore, in the search for carbon neutral buildings these natural materials should be submitted into research and testing for whole life cycle analysis, stiffness, strength, fastener withdrawal resistance and durability, and also scope can be made on developing hybrid products where its fibrous qualities can be applied. The second is that in a world with a rapidly increasing population there may not be sufficient conventional resources for all in the future, and people will need to turn to resources that they can grow in a sustainable way, even more in such cases like the agave plant with its multiple potential uses and applications. For these reasons it seems sensible not to dismiss materials like Agave but to undertake serious investigation of their properties. This is the next research step to be undertaken.

As a conclusion the future of Agave as a building material or as a plant with many potential uses in New Zealand, or anywhere else, that can be recorded and has potential to be cultivated, developed and even improved by developing a scientific and methodological set of tests, the successful development will depend more on the cultural value of its many uses. Traditional crafts and skills developed in Mexico are to be regarded as a good stepping stone of what can be done with this species in terms of natural low impact and sustainable practices and resources. Through the indigenous knowledge of these plants regarding this work done by the Otomis and other indigenous groups in places like the arid highland of Mexico, it can be seen that experimenting into its many possibilities and uses, , is a matter of adapting and developing its many beneficial possibilities in health, land restoration, and as a bulk material of potential building applications. This is not a technical problem, were cultural investigation and practical experimentation are regarded as fundamental..

The potential use of this plant in building industries is alike to the case of native plants that are no longer considered as building material, like Raupo reed, New Zealand flax, Nikau Palm or other fibrous material found in New Zealand. In any case a matter on researching its indigenous knowledge and application is regarded as the key for developing modern processes, products or industries related to the use of renewable natural plant materials.

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