THE LANDMARK ARCHITECTURES IN THE KAKIOKA MAGNETIC OBSERVATORY

Kimihiro Nishimura

Ibaraki Prefectural Government, City Planning Division, Japan

*Email:*kiminishi26@yahoo.co.jp

ABSTRACT

There are six landmark architectures in the Kakioka Magnetic Observatory. The characteristics of these buildings are as follows:(1) The variation building is a semi-underground granite building that has two advantages: one is stability at room temperature in the basement, and the other is low humidity in the room above ground.(2) The thick walls of the magnetic laboratory, the new variation building, and the new absolute building are made of unusual white brick. (3) The ornamentation found on the facade of the magnetic laboratory, the office building, and the electrometer hut show influence from the building design trends of the era, and the office building is one of the first examples of Spanish detail implementation in modern Japan.

Keywords: Kakioka, Magnetic Observatory, Semi-underground, White brick, Spanish architecture

1 INTRODUCTION

Routine geomagnetic observations in Japan began at Azabu-Imaimachi, Tokyo in 1883, during the First International Polar Year (1882-1883). The observatory moved to the Central Meteorological Observatory, which was located on the former site of Edo Castle, Tokyo, in 1886. However, the observatory moved to Kakioka in 1912 because disturbances due to Tokyo's electric tramway had increased. Furthermore, the expansion of the site and the enlargement of buildings were accomplished from 1924 through 1925 and became appropriate facilities for Japan's standard observatory (Kakioka Magnetic Observatory, 1983). Six original buildings still exist at Kakioka (Fig.1). These buildings were investigated by Kimihiro Nishimura (2008, 2009). New findings about these buildings are shown in this study: a survey of the situation of the Japanese Magnetic Observatory at dawn and a study of the architectural features of the six landmark architectures using documents in the possession of the Kakioka Magnetic Observatory, Japan Meteorological Agency, and others.

Figure 1. Kakioka Magnetic Observatory (office building)

2 THE DAWN OF GEOMAGNETISM OBSERVATION IN MODERN JAPAN

2.1 The Magnetic Observatory of the Central Meteorological Observatory

The variation building of the Central Meteorological Observatory in Kojimachi Daikancho in Tokyo was built underground in about 1887. Observations in it were carried out by trial and error because the basement with a stable room temperature was easily penetrated by groundwater. Therefore, the variation building was rebuilt in 1896. There were two rooms in the basement with a staircase running in a N-S direction between them. A Mascar's self-registering magnetograph was located in the eastern section, and an apparatus for direct reading was in the western section (Kakioka Magnetic Observatory, 1983).

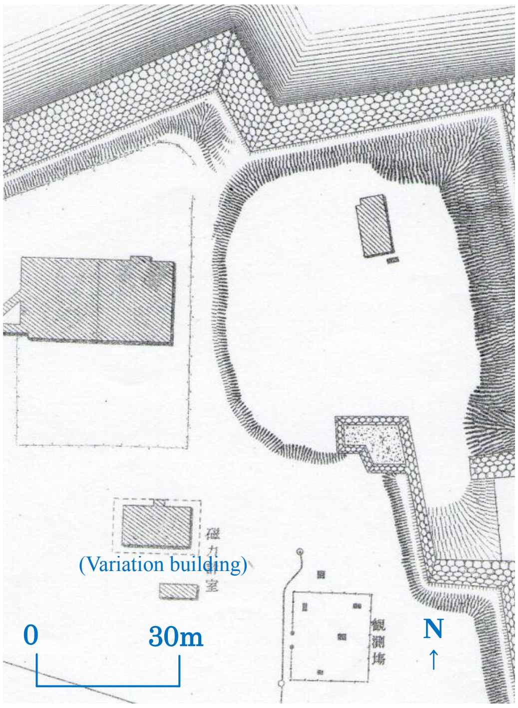

Figure 2. Site of the Central Meteorological Observatory (adapted from Central Meteorological Observatory, 1901)

According to records from the Central Meteorological Observatory (1901) and the Central Meteorological Observatory (1908), the variation building was located nearer the center east of the site (Fig. 2). The building was constructed of wood; all nails were made of copper, and the supports for instruments were made of marble and placed on the masonry work of white bricks that were free of magnetic ingredients. The drawing of this building has not been discovered, but, according to documents and drawings in Tokyo University's possession (Tokyo Imperial University, 1901), the Magnetic Observatory built by Tokyo Imperial University in Kamigamo, Kyoto in 1902 is of a similar structure (Nishimura, 2011). This observatory has two rooms with granite double walls and a staircase running in the N-S direction between them (Fig. 3). How would the observer and designer conceive the idea of this basement and two rooms with staircase? A figure of a similar basement structure appears in "An Annual Report of the Potsdam Magnetic Observatory 1890-1891", which is in the Kakioka Magnetic Observatory's possession (Fig. 4). It is thought that the observer and designer referred to this report.

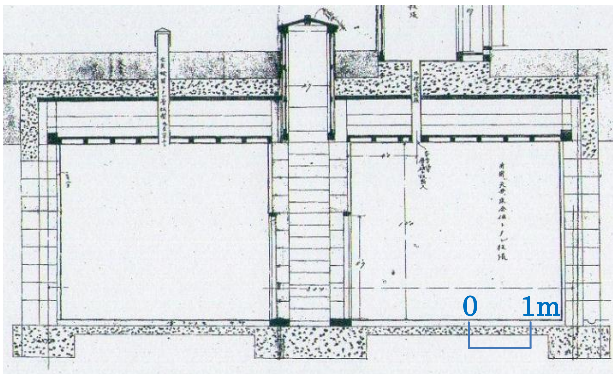

Figure 3. Kamigamo Magnetic Observatory, Japan (adapted from a copy at Kyoto Imperial University (1910) which is more vivid than the copy in Tokyo University's possession)

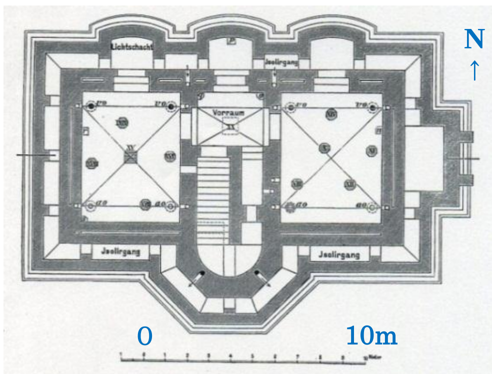

Figure 4. Potsdam Magnetic Observatory, Germany (basement) (adapted from Koniglich Preussischen Meteorologischen Instituts, 1894)

2.2 The Magnetic Observatory of the Imperial Earthquake Investigation Committee

According to Nakamura and Tanakadate (1894), the magnetometer rooms that were completed in Nagoya and Sendai in August, 1893, featured a triple frame structure above the ground (Fig. 5). A basement would have been suitable for geomagnetism observation in terms of small temperature changes. However, it would have been humid in the basement, and its brick would have contained iron and have disturbed the observation. In addition, magnetometer rooms of the same structure were built in Kumamoto and Nemuro (Nakamura, 1943).

In a similar vein, according to Fleming and Bauer (1903) and Hazard (1909), the Cheltenham Magnetic Observatory in USA was constructed in 1901. This observatory was designed by J. A. Fleming under the guidance of W. C. Bauer. The magnetometer room of the Cheltenham Magnetic Observatory featured a triple wooden frame structure built above ground measuring 36 ft by 56 ft with a height of 24 ft (Fig. 6). In addition, magnetometer rooms of the same structure were built in Honolulu, Hawaii and Sitka, Alaska in 1901. Bauer and Fleming also pointed to low humidity and construction costs as determining factors for deciding on an above ground observation room. This closely resembles the thinking of Nakamura and Tanakadate (1894).

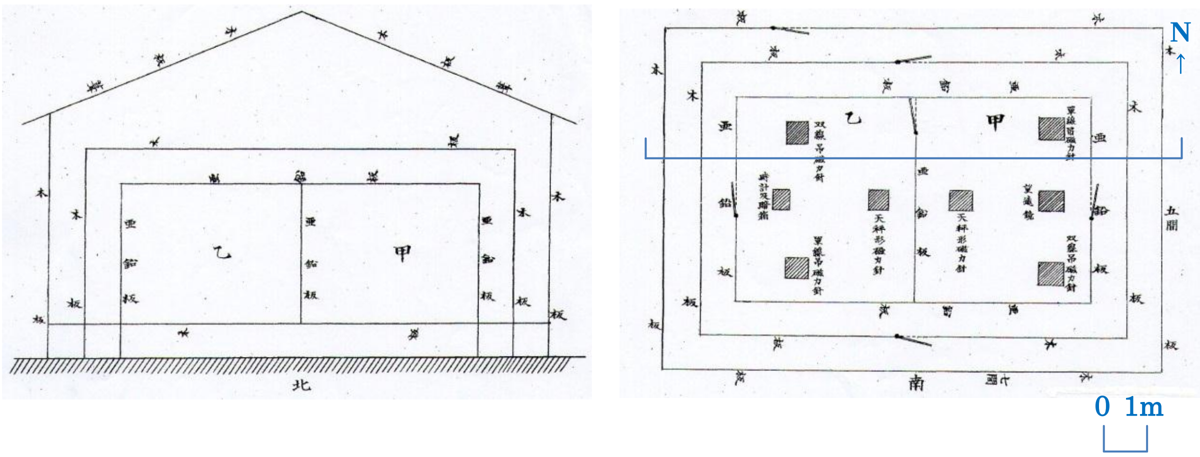

Figure 5. Magnetometer room of the Imperial Earthquake Investigation Committee (adapted from Nakamura and Tanakadate, 1894)

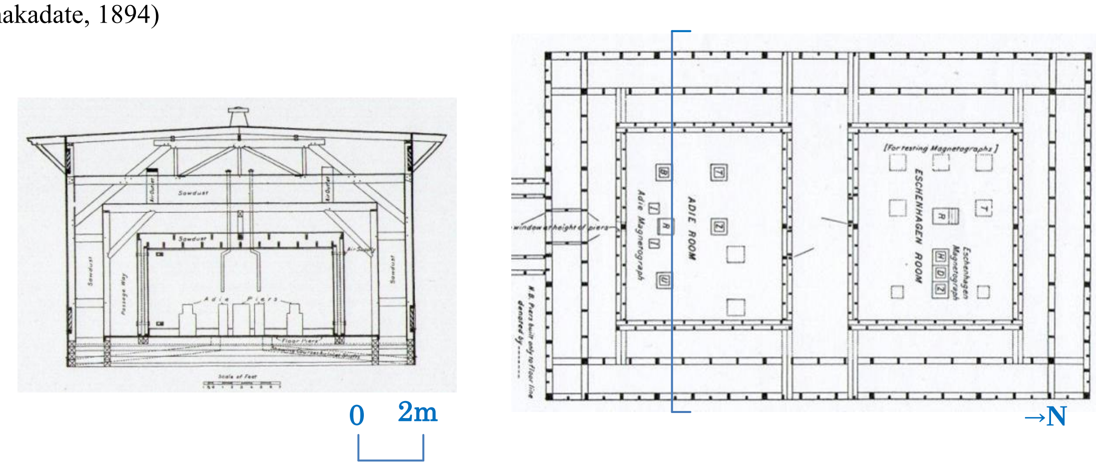

Figure 6. Magnetometer room of the Cheltenham Magnetic Observatory (adapted from Fleming and Bauer, 1903)

2.3 Different types of observatories

It is clear that there were two types of observation at the dawn of geomagnetism observation in modern Japan. One type was in a basement, such as in the Magnetic Observatory of the Central Meteorological Observatory and the Kamigamo Magnetic Observatory. The basement was suitable for observation because room temperature was kept fixed. However, it was humid and this presented problems.

The other type of room was above the ground, such as those of the Magnetic Observatory of the Imperial Earthquake Investigation Committee. An above the ground room was suitable for observation because the room humidity was low. However, changes in the room temperature also created problems.

A similar tendency is seen in magnetic observatories in other countries. According to annual reports, magazines on the geomagnetic field, and so on, examples of basements observatories included Kew, England (Okada, 1933), Parc St Maur, France (Okada, 1933), Potsdam, Germany (Fig.7), Uccle, Belgium (Fig. 8), and so on. Examples of above ground rooms included Greenwich, England (Fig. 9); Cheltenham, USA; Honolulu, Hawaii; Sitka, Alaska; Alibag, India (Fig.10); La Kia-Pang, China (Fig. 11), and so on. In addition, semi-underground observatories were found in Rude Skov, Denmark (L'Institut Meteorologique de Danemark, 1911); Tsingtau China (Central Meteorological Observatory, 1931a), and so on.

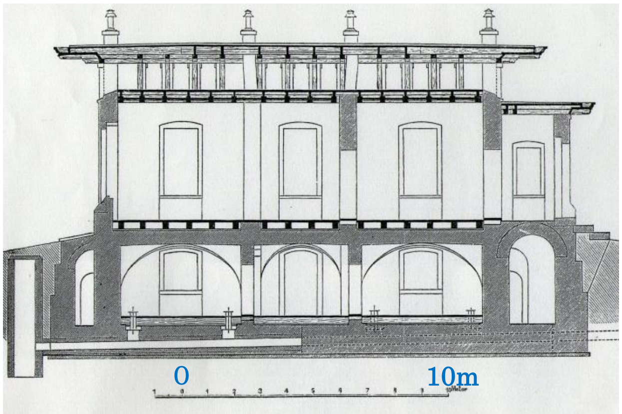

Figure 7. Potsdam Magnetic Observatory, Germany (adapted from Koniglich Preussischen Meteorologischen Instituts, 1894)

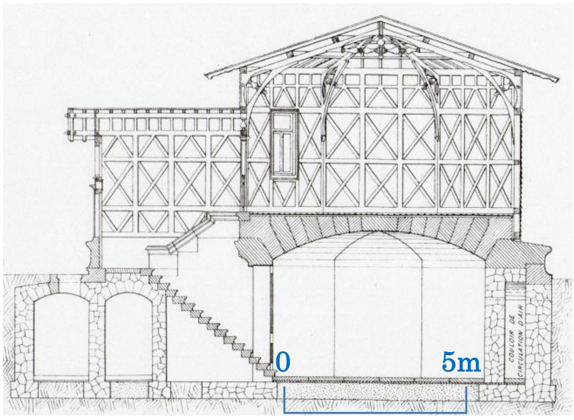

Figure 8. Uccle Magnetic Observatory, Belgium (adapted from Lecointe, 1905)

Figure 9. Greenwich, England (Maunder, 1900)

Figure 10. Alibag, India (Moos, 1913)

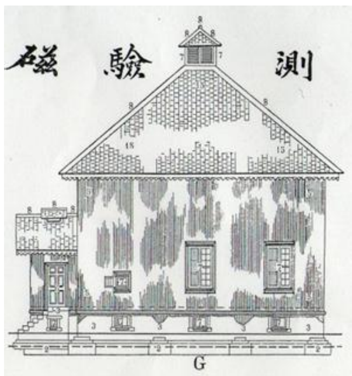

Figure 11. La Kia-Pang, China (Observatoire de Zi-Ka-Wei, 1911)

3 FORMATION OF THE KAKIOKA MAGNETIC OBSERVATORY

The absolute building (26 sq m) and the variation building (32 sq m) were built in Kakioka in December, 1912. These buildings were designed by Tokuichi Yoshida（Kakioka Magnetic Observatory, 1983).

According to the Central Meteorological Observatory of Japan (1917, 1926a), Kakioka is a small town in Ibaraki Prefecture, Eastern Japan and is situated to the east of Mt. Tsukuba. The railway station nearest to the town is Ishioka, which is 12 km from Kakioka. The site of Kakioka is free from any electric traffic disturbance (Fig. 12).The absolute building was built in the south, and the variation building was built in the west of the site (Fig. 13, Fig. 14). The absolute building was a wooden building. In its construction, utmost care was taken to exclude all materials that might possibly affect the magnets. The roof of the building was covered with copper plates carefully tested as to their non-magnetic nature before they were used.

The variation building is a semi-underground granite building. The building is characterized by soil piled on its roof to avoid changes in temperature. To endure the soil pressure, the roof is an arch. Along with a vestibule, the building has two rooms. The east room is again divided into two apartments by a wooden partition. In the west room the variometer was placed on marble pillars The recording part of the instrument was placed on another marble pier in the south apartment of the east room, a small window in the partition allowing the rays of light reflected from the variometers to fall upon the photographic paper of the recording apparatus. In the northern apartment of the east room, a mercurial thermometer was inserted in the granite wall that separated the apartment from the west room. The bulb of the thermometer protruded into the west room so that the temperature of the west room might be observed without entering into it. By means of both instruments the temperature of the air in the variation building was observed (Fig. 15).

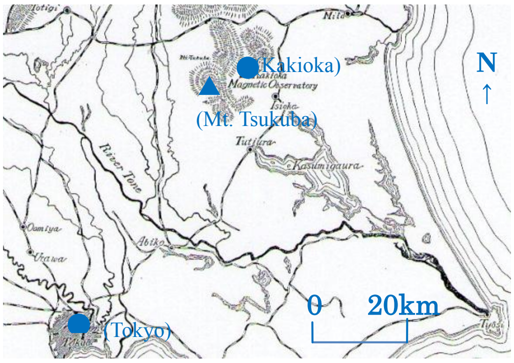

Figure 12. Kakioka in Ibaraki Prefecture (adapted from Central Meteorological Observatory of Japan, 1917

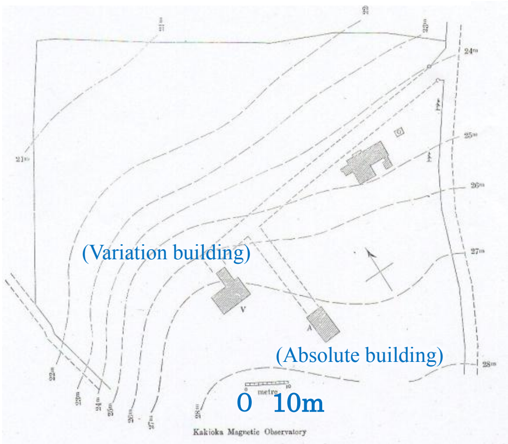

Figure 13. Site of Kakioka, 1912 (adapted from Central Meteorological Observatory of Japan, 1917)

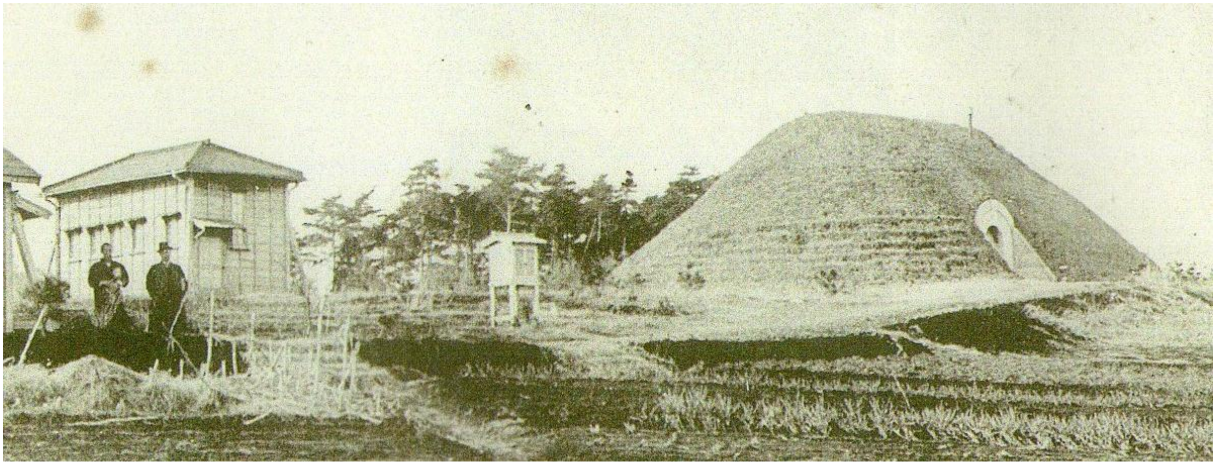

Figure 14. Absolute building (left) and variation building (right) (Central Meteorological Observatory of Japan, 1917)

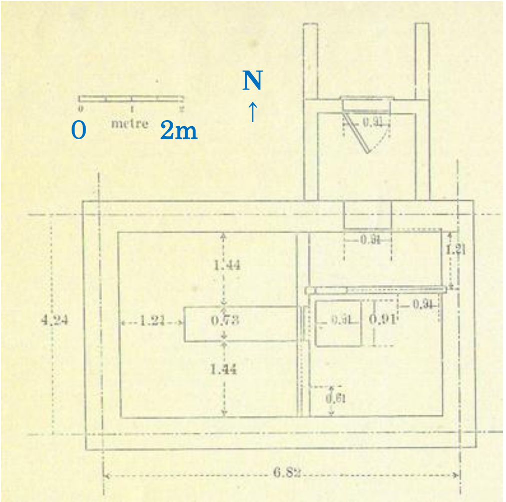

Figure 15. Plan of variation building (adapted from Central Meteorological Observatory of Japan, 1917)

By the way, how would the observer and designer come up with this semi-underground granite building divided into many rooms? An illustration of Rude Skov in Denmark with piled soil on its roof and many rooms to reduce the temperature change appears in *L'Institut Meteorologique de Danemark* (1911), which is in Kakioka Magnetic Observatory's possession (Fig. 16, Fig. 17). It is thought that these characteristics of the Japanese observatory were influenced by the plans of the Rude Skov Observatory.

In addition, after the Great Kanto Earthquake in 1923, the soil on the roof of the Kakioka variation building was removed and repaired (Central Meteorological Observatory of Japan, 1926b Fig.18), and the roof was thatched in 1937 (Fig.19). Fig.19 is from the Imamichi collection, a group of photo albums by S. Imamichi, the first director of the Kakioka Magnetic Observatory.

Figure 16.Variation building at Rude Skov (*L'Institut Meteorologique de Danemark*, 1911)

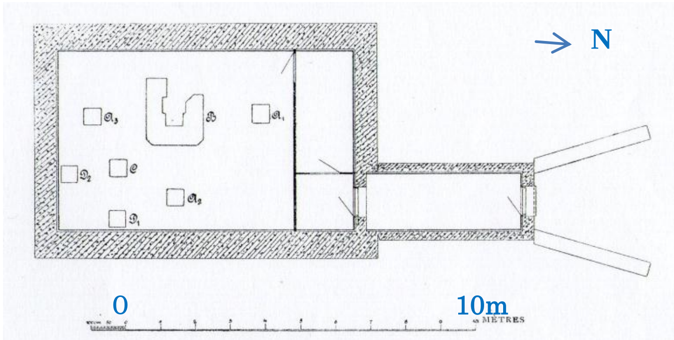

Figure 17. Plan of Rude Skov's variation building (adapted from L'Institut Meteorologique de Danemark, 1911)

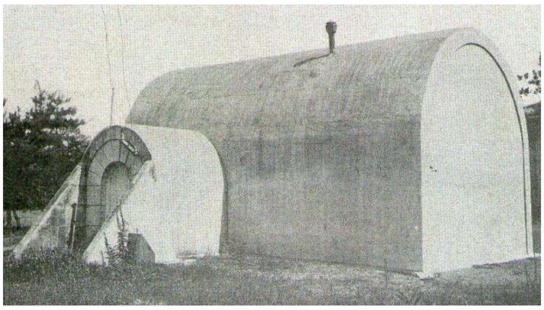

Figure 18. Variation building 1925 (Central Meteorological Observatory of Japan, 1926b)

Figure 19. Variation building, 1937 (Imamichi collection)

This variation building had two advantages: one was stable room temperature in the basement and the other was low humidity in the room above ground. According to Kuboki (1976), the variation building came to stand out in the site because of its roof, which was thatched with the aim of reducing room humidity.

4 EXPANSION OF THE KAKIOKA MAGNETIC OBSERVATORY

The Kakioka Magnetic Observatory suffered quite a bit of damage in the tremendous Kanto earthquake of September 1, 1923, and unfortunately, almost all the photographic records of Kakioka were lost from the Central Observatory in Tokyo in the big fire following the earthquake. Therefore, new buildings were built at Kakioka: the magnetic laboratory (32 sq m) in May, 1924, the new variation building (47 sq m), the new absolute building (33 sq m), the office building (215 sq m), the electrometer hut (33 sq m), and so on in August, 1925 (Kakioka Magnetic Observatory, 1983).

4.1 Construction in 1924

According to the Central Meteorological Observatory of Japan (1926a, 1931b), the Imamichi collection, Imamichi (1938), and the property ledger of the Kakioka Magnetic Observatory, the magnetic laboratory with the copper roof and the nonmagnetic white brick walls was built in the south of the site (Fig. 20). This one story building, 6.3 m long and 6.3 m wide, has a wall thickness of 0.5m. In the northern part of the building are a variometer room and a recorder room while in the southern part of the building are a laboratory room and a hall. Decoration on the facade is a motif of a plant (Fig. 21). According to Yoshimizu (2002), this decoration is in Jugendstil, the German version of Art Nouveau.

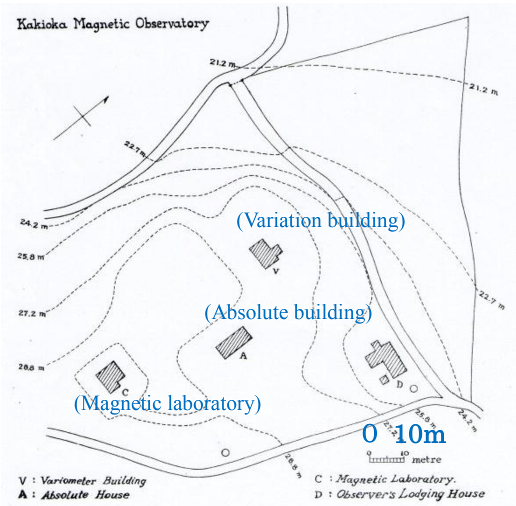

Figure 20. Site of Kakioka in 1924 (adapted from Central Meteorological Observatory of Japan, 1926a)

Figure 21. The magnetic laboratory (adapted from the Imamichi collection)

4.2 Construction in 1925

According to the Central Meteorological Observatory of Japan (1926b, 1931b), the Imamichi collection, Imamichi (1938), and the property ledger of the Kakioka Magnetic Observatory, four new buildings were completed in 1925: the new variation building, the new absolute building in the west, the office building in the east, and the electrometer hut in the southwest side of the large site (Fig.22).

The new variation building with a copper roof and non magnetic white brick walls has one story and is 9.6 m long and 3.5 m wide (Fig. 23). This building has a lobby on its eastern side and also is divided into two rooms. A recording apparatus was located in the east room while a set of Eschenhagen-Schmidt's variometers were in the west. An electric light was used as a light source for the magnetograph. Precautions were taken to keep the daily temperature range in the room negligibly small. The walls are double with an air space of 0.3 m between them to reduce temperature change, and the total width of the double walls and air space is 1.0 m.

The new absolute building with a copper roof and nonmagnetic white brick walls has one story, is 7.3 m long and 3.6 m wide (Fig.24), with a small lobby on its eastern side. Precautions were taken to prevent any sudden change in room temperature; there are double windows, and the walls are 0.5 m thick. In winter the air was heated to a suitable temperature by an electric heater. There are three pillars in the building.

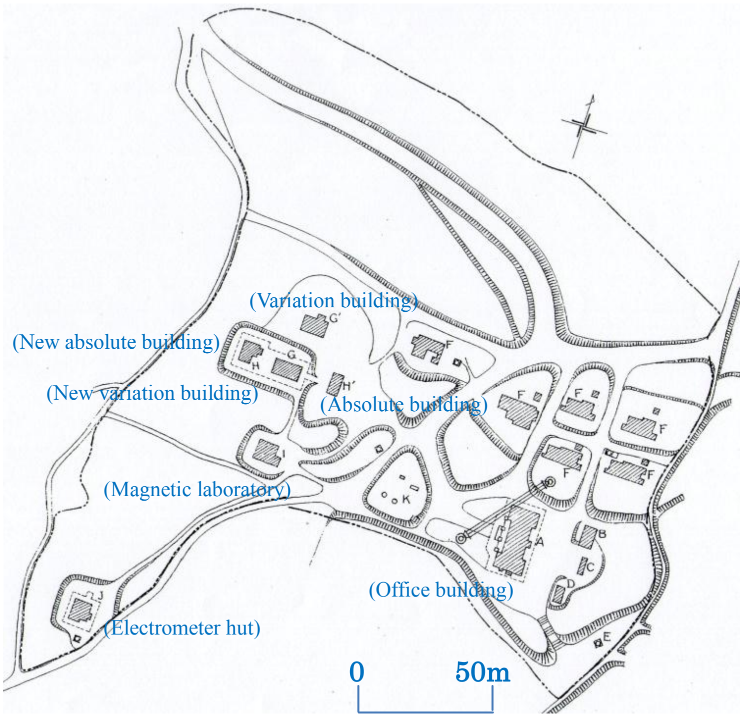

Figure 22. Site of Kakioka, 1925 (adapted from the Central Meteorological Observatory of Japan, 1926b)

Figure 23. The new variation building (Imamichi collection)

Figure 24. The new absolute building (Imamichi collectiom)

The office building is made of steel reinforced concrete. It has one story, is 23.1 m long and 11.2 m wide. The roof is made of red tile; the walls are bright colors; it has three arched windows and a porch; there are Spanish style and classic ornamentations on the window sashes and eaves (Fig. 25). Originally, this building had seven main rooms: two rooms on either side of the southern arched entrance, the east one serving as a library and the west as a computation room; two rooms in the center part with the main arched entrance, the north one serving as an observer’s lodge and the south as a reception room; three rooms on the northern part, the east one serving as an instrument-room and the west as a seismometer room, with Wiechert’s horizontal and vertical seismographs, and the center as a clock room with Riefler’s normal astronomical clock.

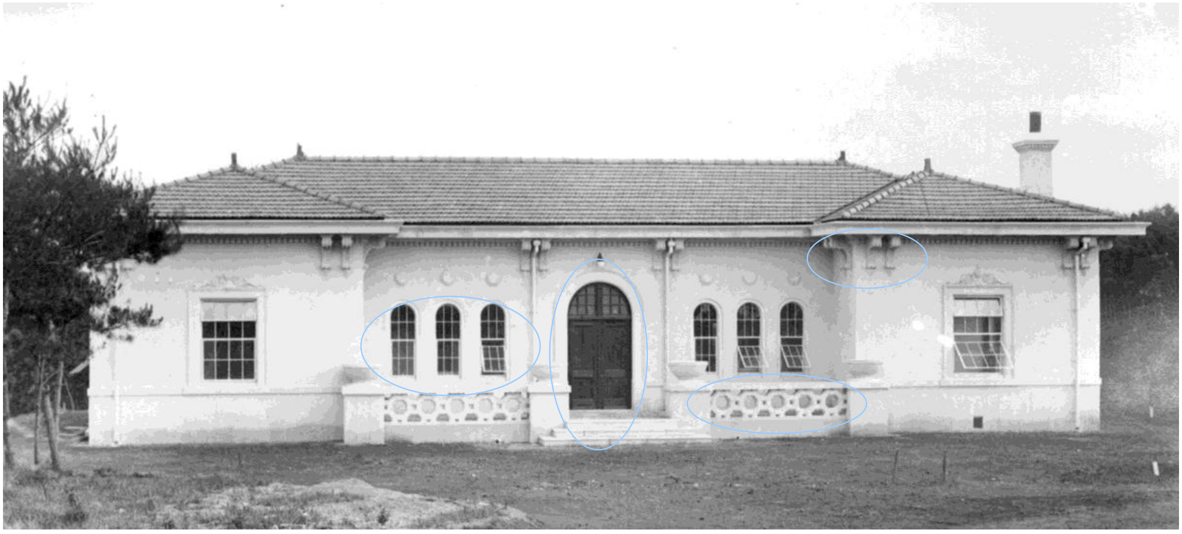

Figure 25. The office building (adapted from the Imamichi collection)

The electrometer hut is made of steel reinforced concrete. It has one story and is 6.3 m long and 5.4 m wide (Fig. 26). This building with classic arch eaves has four rooms. The northern room is equipped with a water drop collector, which records the variations of the electric potential of air.

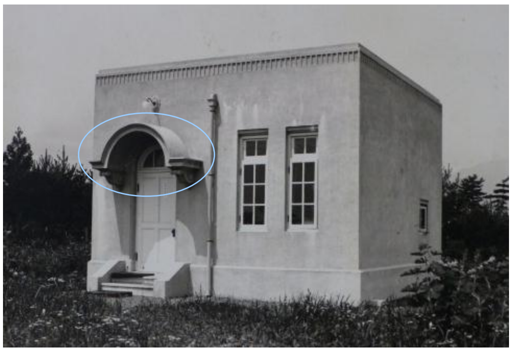

Figure 26. The electrometer hut (adapted from the Imamichi collection)

4.3 White brick and Spanish constructions

Okada (1933), who was a director of the Central Meteorological Observatory, wrote that the office building and so on were designed by the Matsushiro Architecture Office after the Great Kanto Earthquake of 1923; however, according to Conversation with Ichiro Niida (1997), Okada had wished for the designs to follow the firm and sturdy nature of German construction. On the other hand, the building was actually designed by an architect called Sato. To support this quote, *The Ministry of Education Directory 1925* says “Appointee Sadajiro Sato of the Ministry of Education architecture section was currently on tour of duty to Kakioka Magnetic Observatory”. Therefore, it can be understood that the construction of these buildings were supervised by Sadajiro Sato from the Ministry of Education architecture section, based on Okada’s ideas.

The construction is first of all characterized by its use of white bricks in the thick walls of the magnetic laboratory, the new variation building, and the new absolute building. This is rather unusual as white bricks are a white colored variant of firebrick, which has been generally only used for kilns where resistance against heat is required (Muramatu, 1979). Even research of magnetic observation rooms at other magnetic observatories conducted by examining journals archived at the Kakioka Magnetic Observatory has revealed no other apparent use of white bricks: common construction materials were timber frame, for example Christchurch, New Zealand (Fig. 27) and Seddin, Germany (Fig. 28) while stone masonry was used for observation rooms, for example De Bilt, Netherlands (Fig. 29) and Helwan, Egypt (Fig. 30).

Figure 27. Christchurch, New Zealand (Farr, 1903)

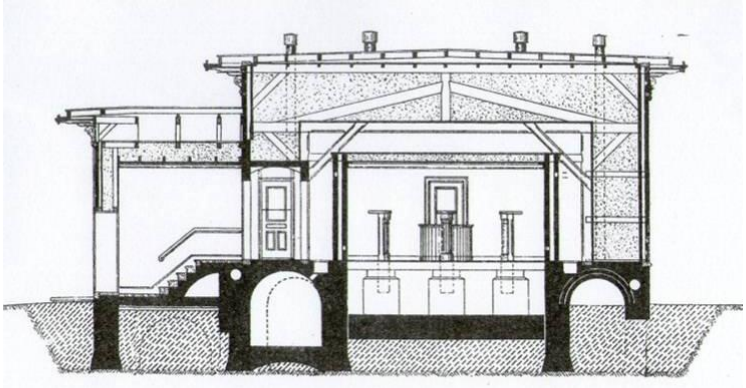

Figure 29. De Bilt, Netherlands (adapted from Snellen, 1900)

0 5m

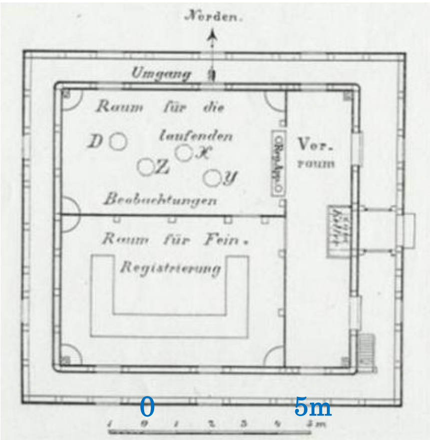

Figure 28. Seddin, Germany (adapted from Koniglich Preussischen Meteorologischen Instituts, 1910)

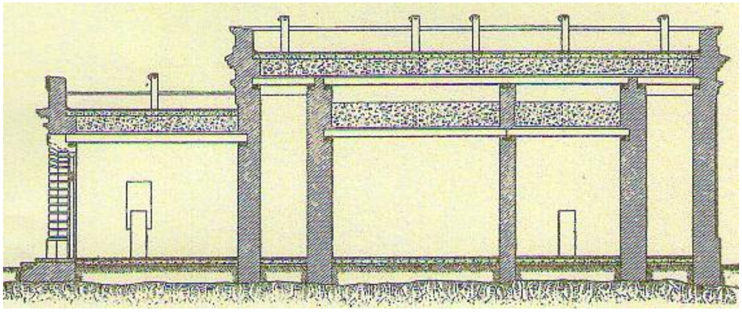

Figure 30. Helwan, Egypt (adapted from Keeling, 1907)

0 5m

The documents show that a budget for the buildings was required by the architecture section of the Ministry of Education. In this budget unit costs of materials for buildings are listed in this order: stone, white brick, reinforced concrete, and timber. It can be assumed that white brick was chosen based on its nonmagnetic, sturdy nature and budget concerns. Also it can be interpreted that Japanese officials from the era based their decisions on their experience with white brick used at the magnetic observatory in Kojimachi Daikancho in Tokyo, thereby creating the unique white brick observatory buildings that originated in Japan.

Meanwhile, influence from the building design trends of the era can also be noted. The Jugendstil style found on the facade of the magnetic laboratory resembles that of the "Karlsruhe Station" (Fig. 31) seen in *Collection of Secession Designs* (1920). Classic ornaments found on the façade of the office building and the electrometer hut resemble that of the "House at Waterbury" featured in *The Architectural Forum, 1919* (Fig. 32) and " House of Louis H. Hayes" featured in *The American Architect and The Architectural Review* (1923) (Fig. 33). In addition, Spanish details are similar to those found in a photograph in the American building magazine, *Western Architect* (1920), "Residence for Davidson" (Fig. 34). At the start of the 20th century, Spanish styles became very popular on the West Coast of the USA, subsequently making their way to Japan. This trend originated in a building designed by Obayashi, exhibited in the Sakuragaoka Home Design Convention of 1922 (Nagata, 2000).

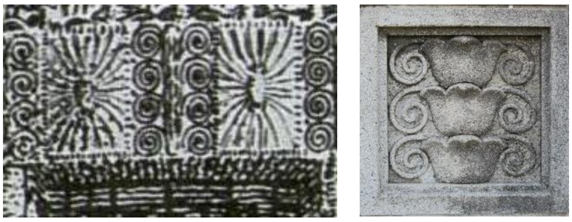

Figure 31. Left: Karlsruhe Station (adapted from *Collection of Secession Designs*, 1920) Right: magnetic laboratory

Figure 32. Top: House at Waterbury (adapted from *Architectural Forum*, 1919) Bottom and left: office building

Figure 33. Left: House of Louis H. Hayes (adapted from *American Architect and Architectural Review*, 1923) Right: electrometer hut

Figure 34. Residence for Davidson (adapted from *Western Architect,* 1920)

It is intriguing that the triple arched windows, an arched entrance, and the balcony of the office building in Kakioka closely resemble that of the building featured in the aforementioned "Residence for Davidson" and Obayashi exhibition (Fig. 35). In the years that followed, the use of Spanish details in construction had exploded in Japan, for example, "Asabuki Residence", 1926 (Fig. 36), "Science building of Kobe College", 1933 (Fig. 37) and so on (Vories & Company Architects, 1937). However, it could be said that the office building of Kakioka is one of the first examples of Spanish detail implementation in Japan.

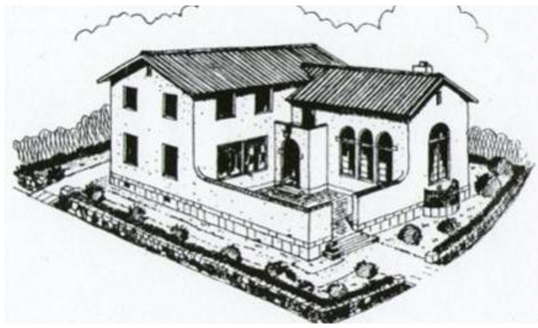

Figure 35. Obayashi exhibition (adapted from *Remodeling House* (1), 1923)

Figure 36. Asabuki Residence (adapted from Vories & Company Architects, 1937)

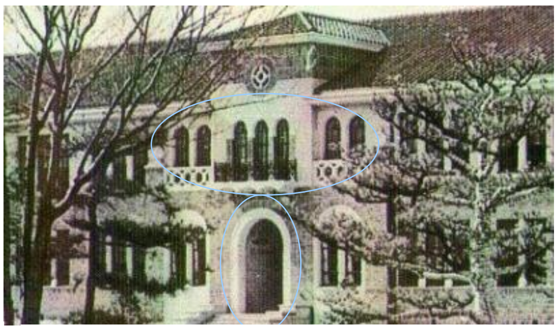

Figure 37. Science building of Kobe College (adapted from Vories &Company Architects, 1937)

5 CONCLUSION

The early geomagnetism observations in modern Japan were performed in a basement or in a room above ground. The variation building of the Kakioka Magnetic Observatory completed in 1912, is a semi-underground granite building which used both types of facility: the first a basement room with stable temperature and the second a low humidity above ground room. In the enlargement of 1924 and 1925, the thick walls of the magnetic laboratory, the new variation building, and the new absolute building were constructed of white brick, which is unusual for the skeleton of a building. It is thought that this material was chosen because it was nonmagnetic, sturdy, and of relatively low cost. The ornamentation found on the facades of the magnetic laboratory, the office building, and the electrometer hut show the influences of the building design trends of the era. Furthermore, the office building is one of the first examples of Spanish detail implementation in modern Japan.

These six landmark architectures convey the history of geomagnetism observation in modern Japan, and it is thought that appropriate preservation and utilization will be necessary in future (Fig. 38).

Figure 38. Kakioka Magnetic Observatory (Top: magnetic observatory, Right: new variation building and new absolute building, Bottom: variation building (left), electrometer hut (right))

6 ACKNOWLEDGEMENTS

I would like to thank everyone at the Kakioka Magnetic Observatory, Meteorological Agency Library, Tokyo University, Kyoto University, Tohoku University, and Ibaraki prefectural government as well as Dr. Monika Korte, Dr. Hans-Joachim Linthe (Helmholtz Centre Potsdam), and Dr. Susan Macmillan (British Geological Survey) for their exceptional cooperation and kindness.

7 REFERENCES

Central Meteorological Observatory (1901) *The calendar of the Central Meteorological Observatory of Japan*, Tokyo, Japan.

Central Meteorological Observatory (1908) *Annual report of the Central Meteorological Observatory of Japan for the year 1905 Part II*, Tokyo, Japan.

Central Meteorological Observatory (1917) *Annual report of the Central Meteorological Observatory of Japan for the year 1913*, Tokyo, Japan.

Central Meteorological Observatory (1926a) *The Annual report of the Kakioka Magnetic Observatory of Japan for the year 1924*, Tokyo, Japan.

Central Meteorological Observatory (1926b) *Annual report of the Central Meteorological Observatory of Japan for the year 1925*, Tokyo, Japan.

Central Meteorological Observatory (1931a) *The Annual report of the Magnetic Observations made at Tsingtau, China for the year 1928*, Tokyo, Japan.

Central Meteorological Observatory (1931b) *The Annual report of the Kakioka Magnetic Observatory of Japan for the year 1930*, Tokyo, Japan.

Collection of Secession designs (1920) Tokyo Japan: Kouyousya.

Conversation with Ichiro Niida (Toya, T) (1997) *Chijiki Kansokujo Tsushin* (473), Kakioka, Japan.

Farr, C.C. (1903) The Christchurch Magnetic Observatory, New Zealand. *Terrestrial Magnetism and Atmospheric Electricity VIII* (1), pp 9-10, Cincinnati, Ohio: University of Cincinnati.

Fleming, J. A. and Bauer, W. C. (1903) The Magnetic Survey of the United States coast and geodetic survey in operation on. *Terrestrial Magnetism and Atmospheric Electricity VIII* (1), pp 11-26, Cincinnati, Ohio: University of Cincinnati.

Hazard, D. L. (1909) *Results of Observations made at The Coast and Geodetic Survey Magnetic Observatory near Honolulu, Hawaii 1902-1904*, Washington Government Printing Office.

House at Waterbury (1919) *The Architectural Forum 30*(5), Plate 68, New York, U.S.A: Rogers and Manson Company.

House of Louis H. Hayes, ESQ. (1923) *The American Architect and The Architectural review CXXIII*, New York, U.S.A: The Architectural and Building Press.

Imamichi, S. Photo albums, Kakioka Magnetic Observatory possession (Imamichi collection).

Imamichi, S. (1938) Kakioka Magnetic Observatory. *Kagaku 8* (1), pp 37-42, Tokyo, Japan.

Imperial Earthquake Investigation Committee (1905) Committee and part-time service. *Reports of the Imperial Earthquake Investigation Committee No.50*, pp 1-3, Tokyo, Japan.

Kakioka Magnetic Observatory (1983) *The geomagnetism observation 100 years history*, Kakioka, Japan.

Keeling, B. F. E. (1907) Helwan Magnetic Observatory. Egypt. *Terrestrial Magnetism and Atmospheric Electricity, XII* (4), pp 149-152, Cincinnati, Ohio, U.S.A: University of Cincinnati.

Koniglich Preussischen Meteorologischen Instituts (1894) *Ergebnisse der Magnetischen Beobachtungen in Potsdam in den Jahren 1890 und 1891*, Berlin, Germany.

Koniglich Preussischen Meteorologischen Instituts (1910) *Ergebnisse der Magnetischen Beobachtungen in Potsdam und Seddin im Jahre 1908*, Berlin, Germany.

Kuboki, T. (1976) *Collection of Tadao Kuboki essays*, Kakioka, Japan.

Kyoto Imperial University (1910) *Property ledger of Kyoto University*, Kyoto University possession Kamigamo Magnetic Observatory became the seismological observatory of Kyoto Imperial University in 1909.

Lecointe, G. (1905) *Annales de L' observatoire Royal de Belgique Editees aux frais de l' etat Nouvelle serie Physique du Globe Tome III,* Bruxelles, Belgique

L'Institut Meteorologique de Danemark (1911) *Annuaiire Magnetique Annees 1907-1908*, Copenhague: L'Institut Meteorologique de Danemark.

Maunder, E. W. (1900) *Royal Observatory, Greenwich, London, England*: The Religious Tract Society.

Ministry of Education architecture section (1924) The documents showing the building budget requirement of the Ministry of Education architecture section in 1924.

Ministry of Education architecture section (1925) *Ministry of Education Directory 1925*, Tokyo, Japan.

Moos, N. A. F. (1913) *Magnetical, Meteorological, and Seismographic Observations made at the Government Observatories, Bombay and Alibag, in the years 1906 to 1910*, Bombay: The Government Central Press.

Muramatu, T. (1979) *The Japanese Modern Architecture Technique History*, Tokyo, Japan: Shoukokusya.

Nagata, M. (2000) *Japan American influence in modern architecture*, Thesis, Tokyo University, Tokyo, Japan.

Nakamura, K. & Tanakadate, A .(1894) Report about the magnetometer room in Nagoya and Sendai. *Reports of the Imperial Earthquake Investigation Committee No.2*, pp 140-144, Tokyo Japan.

Nishimura, K (2008) A Study on buildings of Kakioka Magnetic Observatory in the Taisho period. *Summaries of Technical Papers of Annual Meeting of Architectural Institute of Japan 2008*, pp 269-270, Tokyo, Japan.

Nishimura, K (2009) A Study on process to build the variation building of Kakioka Magnetic Observatory. *Architectural Institute of Japan Kanto Branch Memoir 5*, pp181-184, Tokyo, Japan.

Nishimura, K (2011) A Study on the building of Kamigamo Geophysical Observatory. *Summaries of Technical Papers of Annual Meeting of Architectural Institute of Japan 2008*, pp 385-386, Tokyo, Japan.

Observatoire de Zi-Ka-Wei (Chine) (1911) *Observations Magnetiques Faites a L' Observatoire de Lu-Kia-Pang Tome I Annee 1908*, Chang-Hai: La Mission Catholique a l' orphelinat de T' Ou-se-we.

Okada, T (1933) *Sokkō sadan*, Tokyo, Japan: Tettou Shoin.

Property ledger (with drawing) of the Kakioka Magnetic Observatory. It is clearer than the structure of the laboratory building is white brick in order to match the original white brick found in the damaged section of the building.

Remodeling house (1) (1923) *Obayashi Exhibition*, Tokyo, Japan: Kouyousya.

Residence for Davidson (1920) Western Architect, 29(10), Plate15, Chicago, U.S.A

Snellen, M. (1900) The Magnetic Observatory at De Bilt, near Utrecht. *Terrestrial Magnetism and Atmospheric Electricity 2*, pp 49-58, Cincinnati, Ohio, U.S.A: University of Cincinnati.

Tokyo Imperial University (1901) *Documents of Kamigamo Magnetic Observatory*. Archives Section of Tokyo University's possessions.

Vories, W. M. & Company Architects (1937) *W. M. Vories &Company Architects. Their work in Japan 1908-1936*, Tokyo, Japan: Johnan Shoin.

Yoshimizu, T., Backhausen, R., Backhausen, J., & GesmbH, S. (2002) *Wiener Jugendstil*, Tokyo, Japan: Sentankan.

(Article history: Received 2 November 2012, Accepted 1 May 2013, Available online 7 June 2013)