Dynamic Characteristics of Great Bronze Buddha of Kamakura using microtremor

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Abstract

The second largest bronze Buddha in Japan built in around 1250AD at Kamakura immediately above the focal region of the 1923 Kanto earthquake. Great Buddha of Kamakura has still remained basically its original shape, though it has been suffered several natural disasters as losing its hall. Especially, although the 1703 and 1923 Kanto earthquakes caused settlement and sliding of the basement over 0.3 m, the body has been not suffered serious damage. This statue was casted in order from the bottom with many joints. The joint between the head and the body was noticed because it is reinforced by FRP, Fiber Reinforced Plastic, at the time of the last major repair in 1961. And ingenuity was exercised to fence off the earthquake motion over 400 Gal with sliding the body on the basement, to reduce the load for the neck during earthquake. This is the first example of the earthquake isolation system for cultural properties in Japan. Over 50 years passed after the last major repair, deterioration of FRP is feared. Concerning safety during earthquake motion, microtremor measurement was conducted. As a result of the preliminary investigation in 2009, the surrounding ground was estimated that liquefaction was occurred at the front and right sides of the basement and the basement suffered damage as settlement. However, it is considered that the propagation of the earthquake motion for the statue was interrupted because of the liquefaction. Thus, it seems that the damage for the statue itself was prevented because of namely the natural isolation system. Additionally in 2013, microtremor of the statue itself was measured for making clear the connection status between the body and the head.

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1. Introduction

Great Buddha of Kotokuin Temple in Kamakura (see Figure 1) is the second largest bronze Buddha in Japan built in around 1250AD. Kamakura locates at the high earthquake activity area in Japan as Figure 2.

Repair report of Showa era (1926-1989) says that although Great Buddha of Kamakura has repeatedly been attacked by several disasters as earthquake, rain storm or flood, the statue itself has still remained its original shape without serious damage until today. Although this statue is outside at present, it had its hall at first and finally lost the hall at the time of disaster in 14 or 15 century. Great Buddha of Kamakura suffered many large earthquakes. At least at the time of the 1703 Kanto earthquake (M7.9 to M8.2) and the 1923 Kanto earthquake (M7.9), these focal regions are shown in Figure 2, although the damage as collapse of the basement and shift and settlement of the statue was reported, the statue itself was not damaged severely. It is interesting why this Great Buddha has not suffered severe damage and

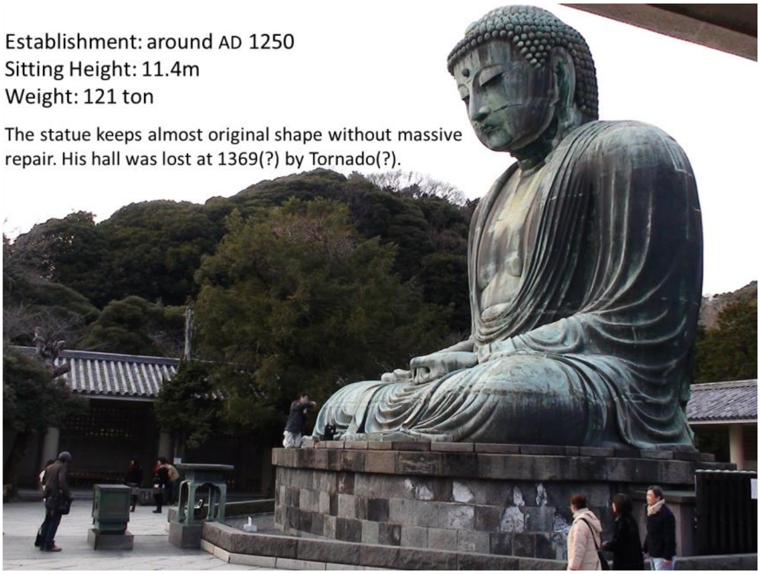


Figure 1. *Great bronze Buddha of Kamakura*

remained the original shape in spite of suffering large earthquake motion repeatedly and collapse of surrounding buildings.

The damage of the 1923 Kanto earthquake was soon repaired, and additionally a major repair in Showa era was done in 1960 to complement the repair for the 1923 damage. At the time of Showa major repair, the neck of the statue was reinforced by FRP, Fiber Reinforced Plastic. With reinforcing the basement and the bottom of the statue by concrete, a stainless steel plate was applied under the reinforced concrete of the bottom of the statue to slide on the granitic block with bush-hammering attached above the basement during large earthquake motion (see Figure 3). This ingenuity is known as the first seismic isolation system for cultural properties in Japan.

Momentum to consider countermeasures for Great Buddha of Kamakura against earthquake motion is increasing again covering the confirmation of the degradation situation of FRP reinforcement for the neck more than 50 years after execution. This paper reports the result

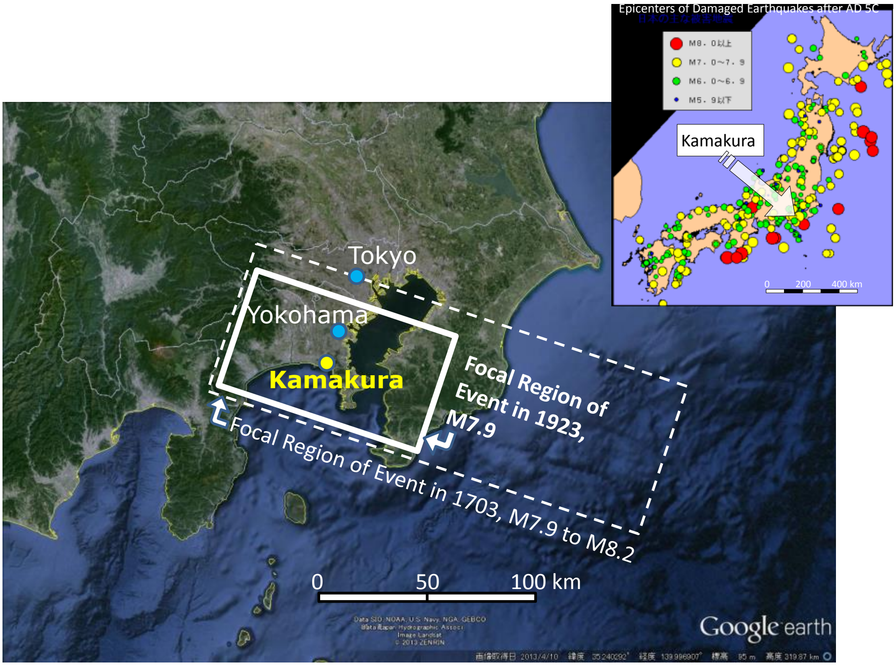


Figure 2. *Location of Kamakura and its surrounding seismicity*

of the microtremor measurement of the statue taken in the result of the preliminary microtremor measurement of the statue and surrounding ground.

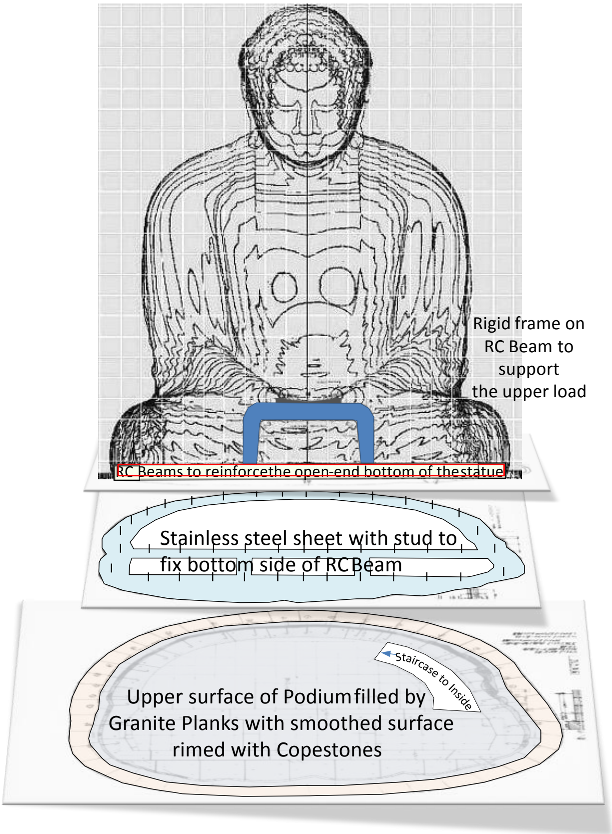


Figure 3. *Base isolation system for the Great Buddha of Kamakura*

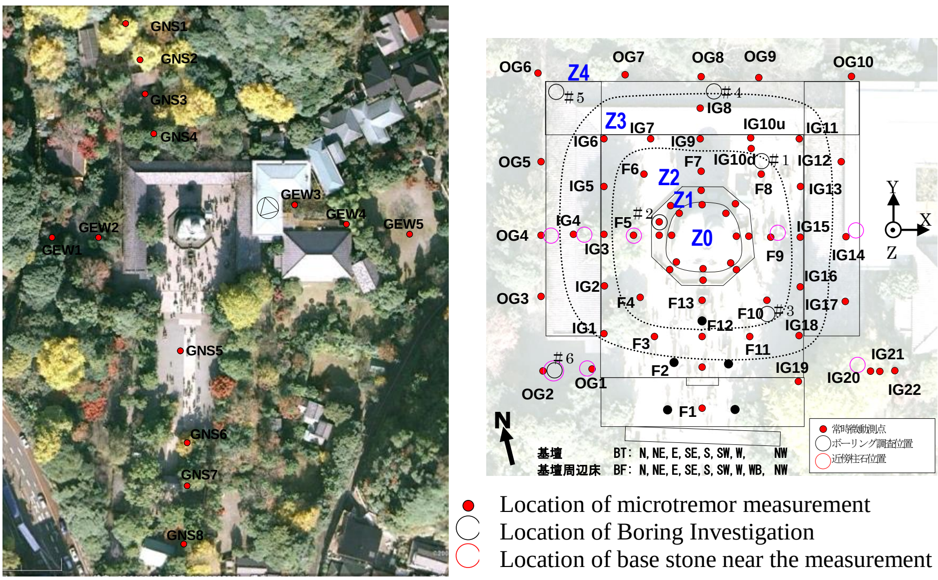
2. Summary of results of the preliminary microtremor measurement of the statue and surrounding ground [2]

Figure 4 shows a distribution of points for microtremor measurement on ground. Figure 5 is QTS (H/V) derived from measurement results. Figure 6 shows the predominant frequency *F* and amplification factor *A* corresponding to the measured location with the value following to the size of the bubble. This figure shows that the ground becomes softer from west to east or from north to south. This is also confirmed from Figure 7 as the distribution of Kg value, derived from F and A as Equation (1).

$$Kg = A^2/F \tag{1}$$

Here, Kg value can roughly estimate the strain of the surface ground multiplying the maximum acceleration value at base ground, so large Kg value corresponds to large shear strain of surface ground caused by earthquake motion.

Next, the relationship between Kg value and the earthquake damage is concerned. The 2011 off the Pacific coast of Tohoku Earthquake occurred two years after the preliminary investigation. This earthquake caused damage for this temple as turnover of some stone lanterns, but some of bronze lanterns were survived. Figure 8 shows the relationship between the damage situation and Kg value measured at near point. Large Kg value is measured near the turnover and small



(1) around corridor *(2) around the statue (Z0)*

Figure 4. *Measurement points of microtremor on ground of Kotokuin Temple*

Kg value is closed to survived bronze lanterns.

Figure 9 shows *Kg* value as a size of bubble at a location corresponding to the damage pictures of Great Buddha at Kamakura shot from three direction at the time of the 1923 Kanto earthquake. It is confirmed that *Kg* value shows good correlation with earthquake damage level or situation. Although *Kg* value around the basement is about 10 at maximum and not so large value, the acceleration was possibly over 500 Gal and the shear strain might reach a few 1000 μ. Therefore, the settlement of the basement over 30cm was estimated to be caused by liquefaction.

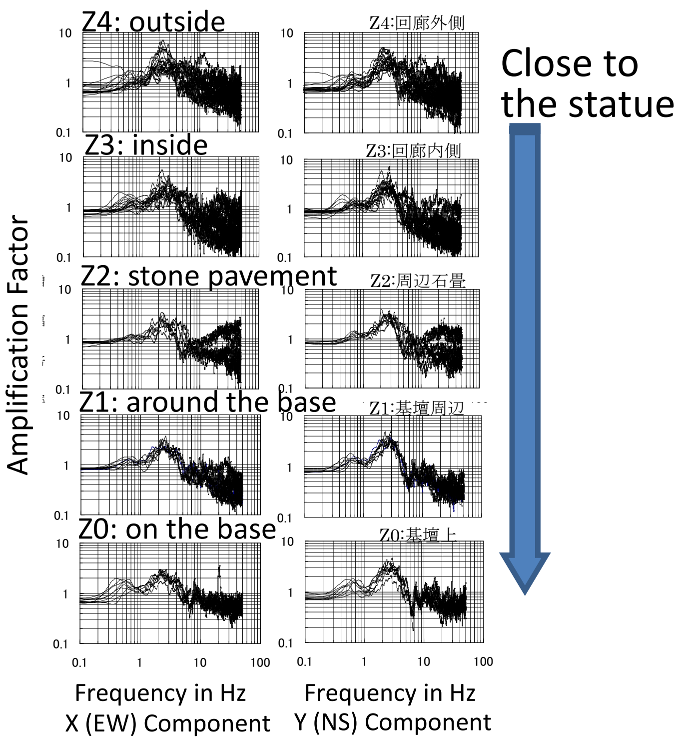


Figure 5. *QTS (H/V spectral ratio) for around of cloister*

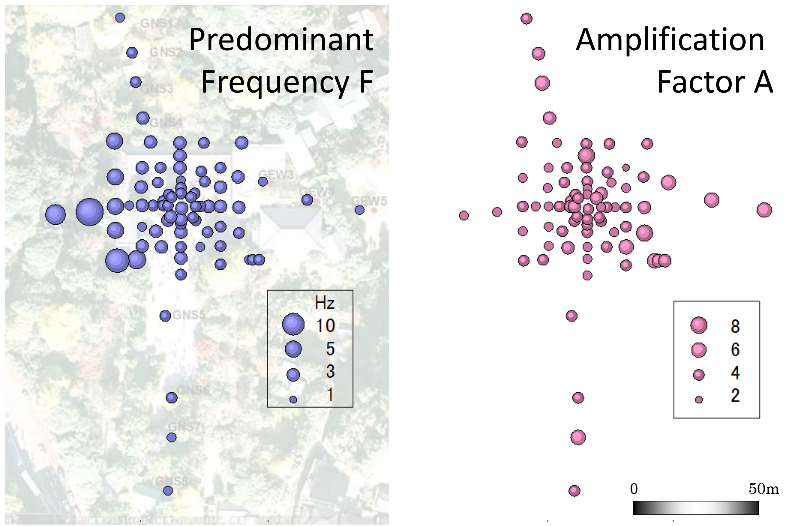


Figure 6. *predominant frequency F and its amplification factor A*

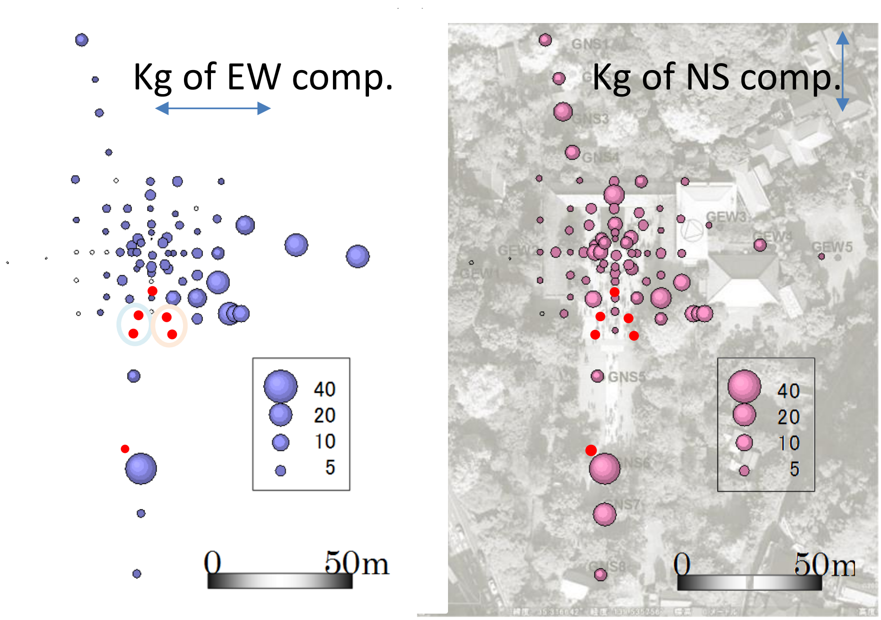
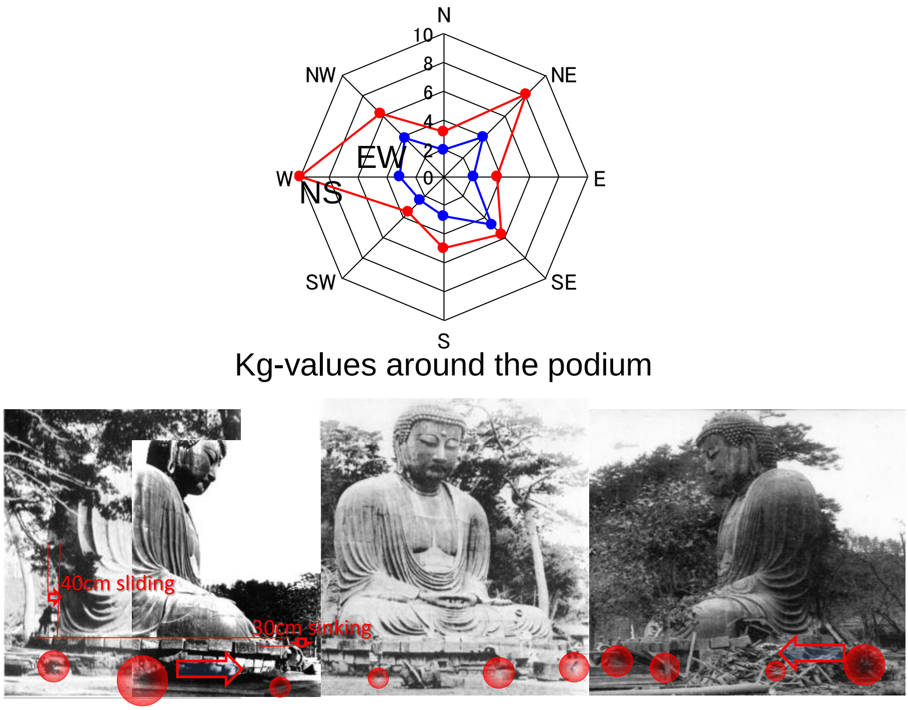


***Figure 7**. Kg-values distribution*

Figure 8. *Damage example by the 2011.3.11 Tohoku earthquake*



(a) West side *(b) South side* *(c) East side*

Figure 9. *Comparison between Kg-values and Damage caused by the 1923 earthquake of M7.9*

3. Measurement situation and analysis method of the Great Buddha

The microtremor measurement was carried out on July 23-25, 2013. Figure 10 shows the distribution of the microtremor measurement points for the main body of the Great Buddha. Figure 11 and Figure 12 show the appearance around measurement points. Here, the three-

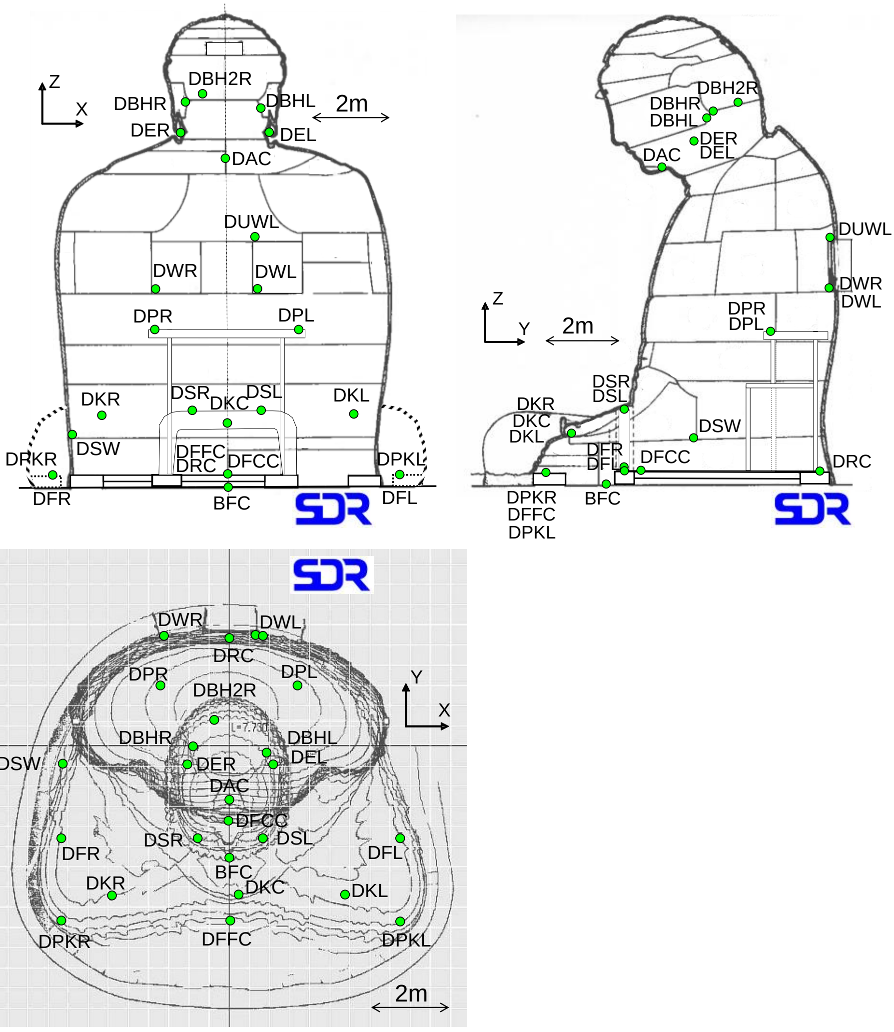


***Figure 10**. Microtremor measurement points in the Great Buddha of Kamakura*

digit number after the site code indicates the date of measurement, for example, 723 means July 23. It was impossible to set the sensor immediately because a small Buddha was placed inside the jaw of the Great Buddha and a money offering was deposited during opening a platform having honor of seeing. However they are removed in the morning at July 25 and it became possible to measure microtremor. The total weight of a small Buddha and a money offering were 155 kg.

On July 25 after removing the small Buddha and a money, microtremor was recorded again at the earlobe measured before July 23 to grasp the change of the dynamic characteristics caused by the variation of the weight, and the vibration characteristics are compared between before and after removing and the change are considered. Also the small Buddha (the weight is 40.4 kg) was put back into place at July 26.

Continuous measurement was carried out at the point DRC under the platform, and the measurement at the other two points was carried out simultaneously standardized by the point DRC. So microtremor of each three points shown in Figure 10 was measured simultaneously to

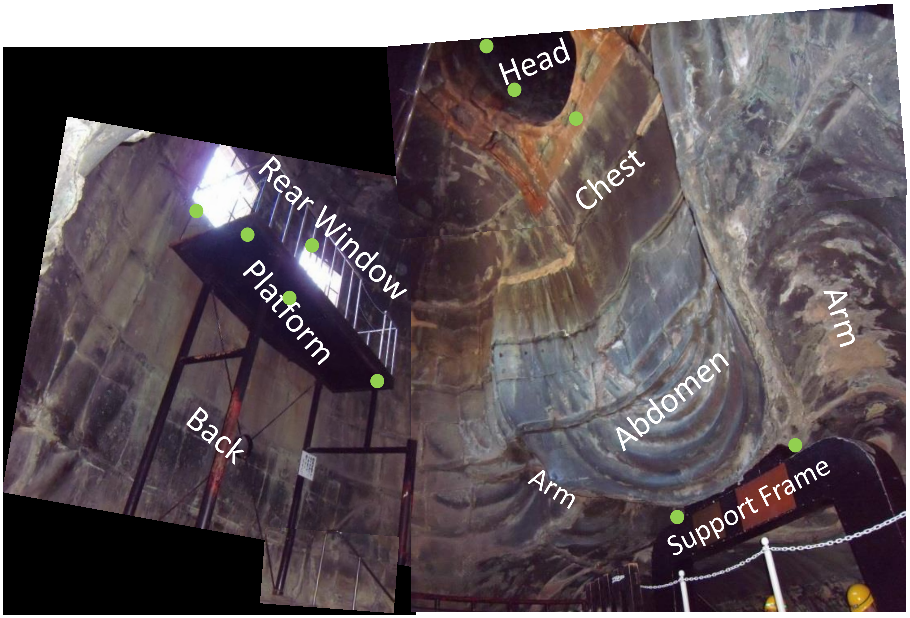


Figure 11. *Inner view of Great Buddha of Kamakura*

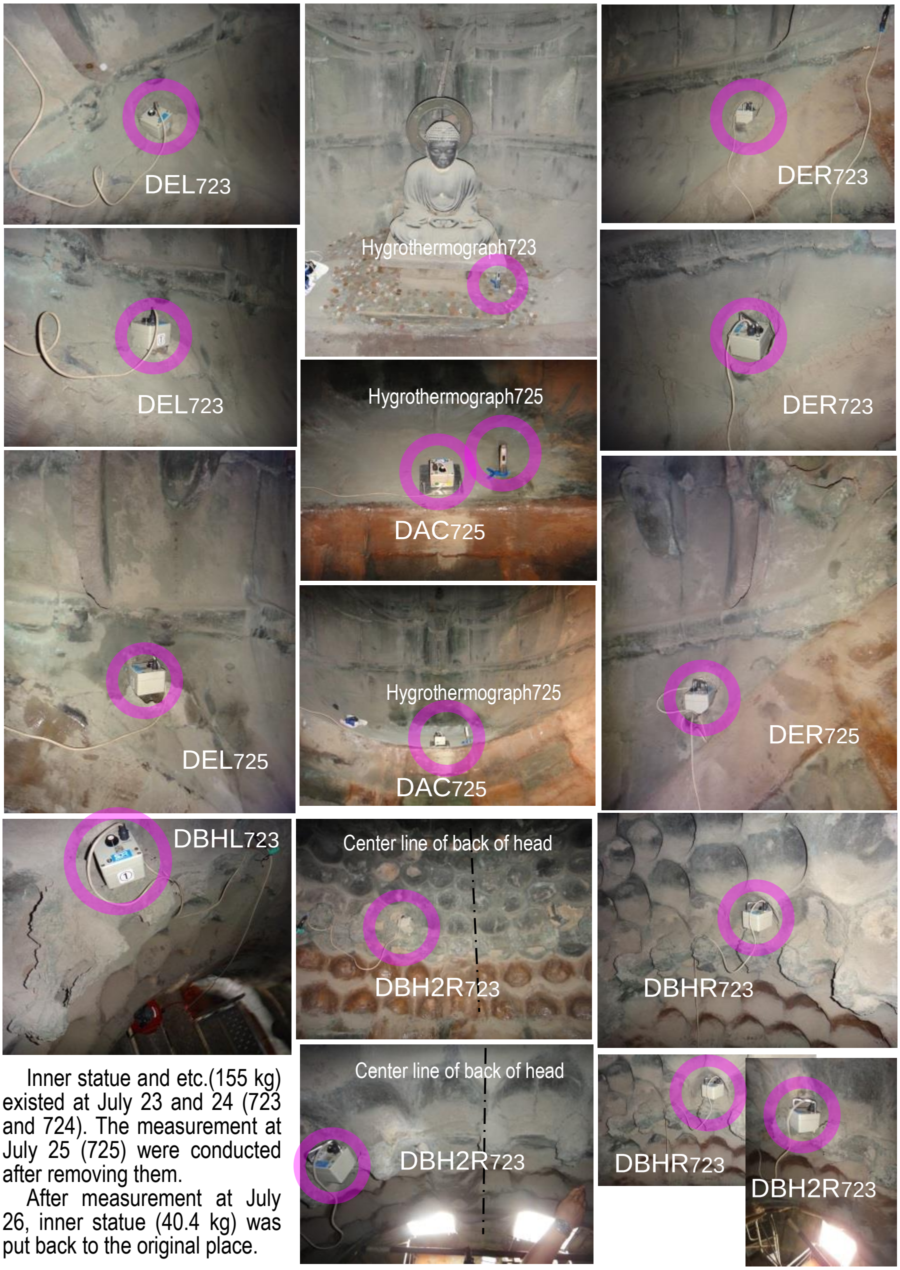


Figure 12. Measurement points in Head

device to have same result of frequency analysis measuring all the point at the same time.

Sampling frequency was set 100 Hz and generally microtremor was recorded for five minutes. More than five analysis sections with 40.96 seconds were chosen from each recorded microtremor and applied frequency analysis, and then an averaged spectrum was calculated

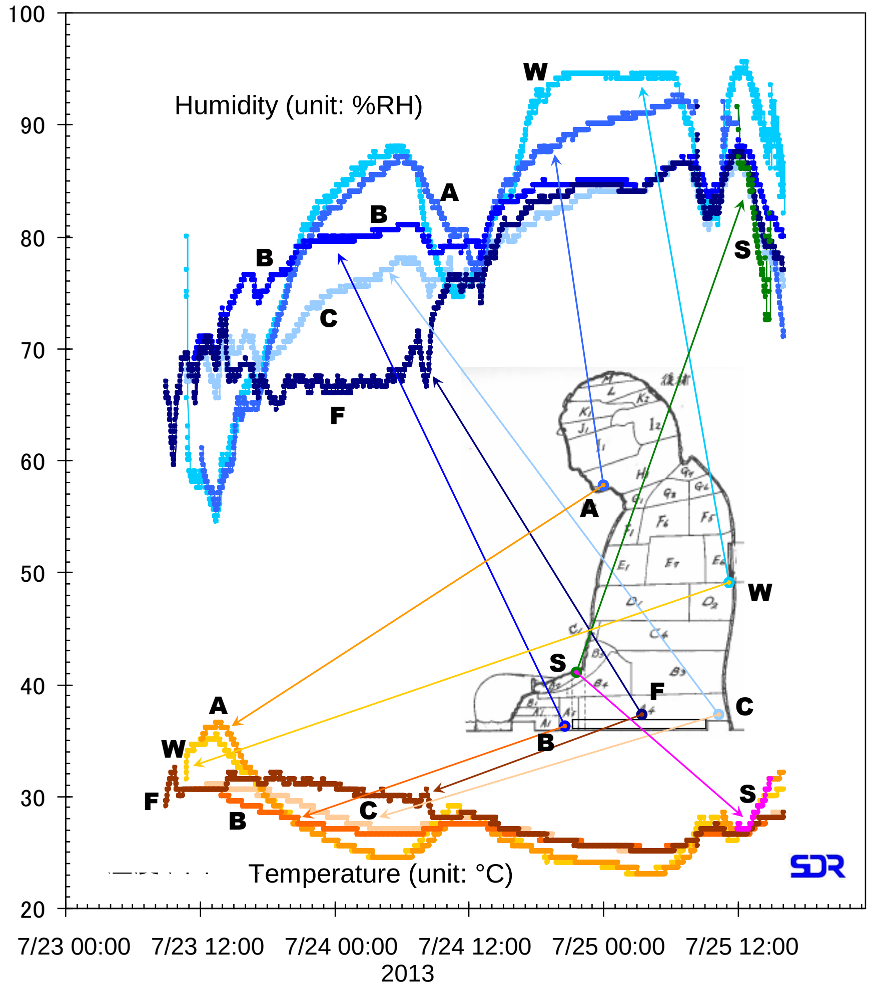


Figure 13. *Change of temperature and humidity at the period of microtremor measurement*

from three to five sections.

On the other hand, because a vibrational trajectory is known to be effective to understand the vibration characteristics [1], here the velocity locus of 60 seconds was drawn and considered to grasp the whole motion.

Microtremor was measured moving points in the daytime and then measured at point DRC and the other point continuously till the next morning. Microtremor was measured at the points DRC, DUWL and DBH2R from the evening of July 23 to the morning of July 24, and at the points DRC, DSL and DSR from the evening of July 24 to the morning of July 25.

A fireworks festival in Kamakura was held 2 km south from the Great Buddha in the evening of July 23 and the vibration of fireworks were also measured. Continuous measurement aimed to observe not only seismic events but also the other vibrations as frictional vibration caused by the change of temperature between the morning and the evening but there was no seismic event.

Because the differences of temperature was not so large shown in Figure 13, the existence of frictional vibration was also not clear. Here, Figure 13 shows the change of the temperature and humidity in every minutes with 0.5 ℃ and 0.5 %RH resolution during microtremor measurement specifying the location of the sensors. It is confirmed from this figure that both temperature and humidity show different behavior at each measurement point in the body.

Although the relationship between the vibration characteristics and the change of temperature or humidity, or the vibration of the fireworks are impressive topics, they will discussed for another day, not in this article.

4. Result of analysis

4.1 Locus of microtremor

Figure 14 shows the locus of microtremor at all the measurement points, projecting to an elevation, a profile and a plan. Background figures of an elevation and a profile are figures of casting joints (see [3]). For a plan background figure is contour map based on the threedimensional measurement [7]. Locus in warm color and cold color indicates the points at right side and center or left side, respectively. According to this figure, it is possible to grasp the vibration situation of each point mentioned below. Notice that these figures include an error with drawing so the center of the locus may not correspond to the measurement point.

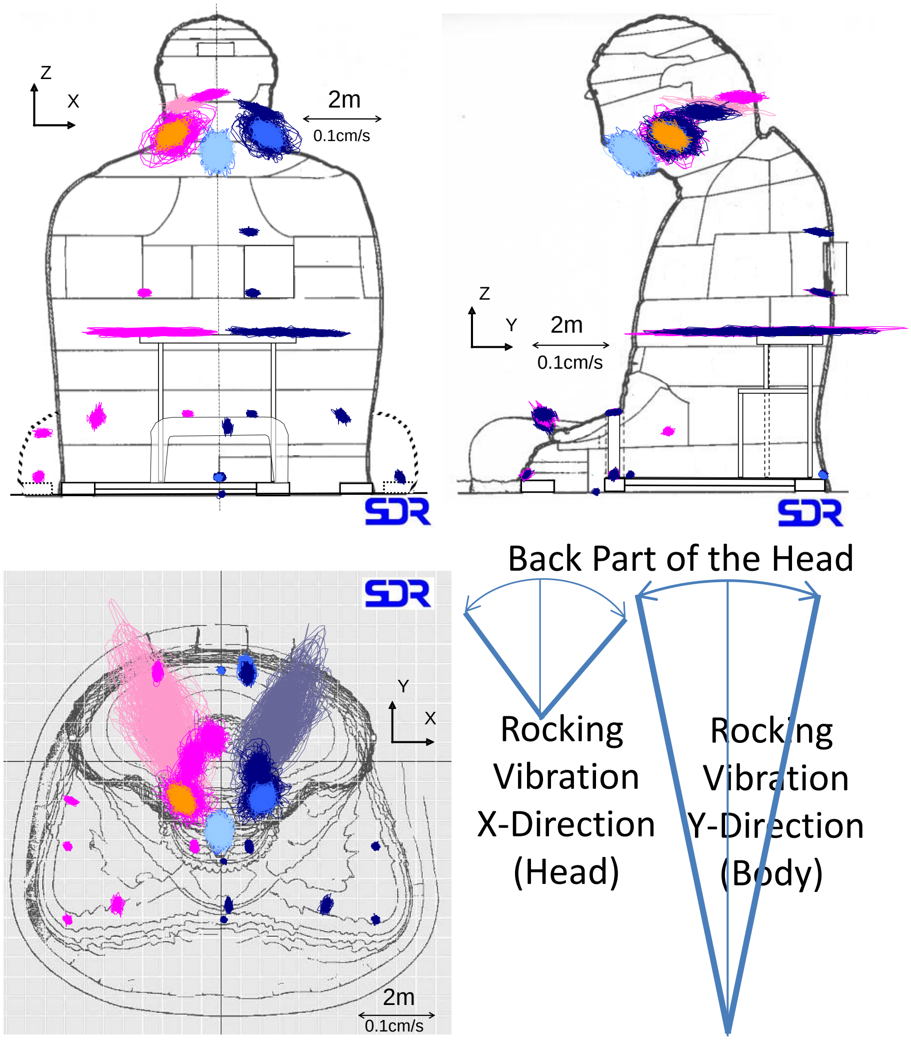


Figure 14. *Locus of microtremor in Great Buddha of Kamakura*

4.1.1 The vibration of a platform having honor of seeing for the inner small Buddha

This platform is a stage inside the body to having honor of seeing for the inner small Buddha and can access the window at the backside. This platform has been not opened to public and removed its stairs about ten years ago. At the time of measurement in 2009, the authors found an evidence that this platform had contacted to the inner wall of the body and it can be estimated that this platform may swing widely during large earthquake motion and attack the inner wall. For this reason, microtremor measurement was carried out for the platform.

The locus of the microtremor is shown in Figure 14, and it can indicate the structural characteristics of this platform. Because the platform consists of the other vibration system from that of the body of the Great Buddha and it is available to show that the structural characteristics appears at the microtremor characteristics, it is explained in rather detail.

The platform is supported by four columns as Figure 11, and the span of the column width is forced to enlarge at left side of the inner body because of the location of the stairs from the entrance putting the column on the intercepting beam. On the other hand, the column span corresponds to the width of the stage and is rather narrow at the right side of the inner body. The horizontal motion predominates in the vibration of the stage, and reflecting the difference of the structure, the locus projected to a profile is seemed falling forward slightly because of a vibration like the rocking vibration in the right side whereas the locus shows almost horizontal shape with slight small horizontal amplitude except for tiny vertical motion because the supporting span is comparatively long in the left side. The tiny vertical motion in the left side seems to be affection of the structure of the column supported by the beam.

As mentioned above, the difference of the structure appears clearly at the microtremor. And it can be understood that sway and torsional vibrations appear clearly on the vibration of the platform projected horizontal plane.

4.1.2 The vibration of the body of the Great Buddha

The vibrations in left and right direction of the body are almost same amplitude regardless of the measured points and it shows well the characteristics of the body of the Buddha broad in left and right direction as the rigid body.

On the other hand, a remarkable tendency can be seen that the vibration in back and forth direction becomes larger toward to higher point of measurement, and it can be estimated appearing the bending vibration including the rocking vibration with the rocking center at the lower part of the basement or the shear vibration.

Anyway, this vibration shows the characteristics of the structure at the measured point and shows comprehensible behavior as rather predominating the vibration corresponding to the motion of the rack where locates in the back of the hand with mudra or crossing leg.

4.1.3 The vibration of the head of the Great Buddha

Six measurement points could be installed in the head as three points at back of the head, one point in jaw and two points at the base of the earlobe. The microtremor locus in velocity is highly distinguishing for each measurement point. One minute long locus of horizontal motion of each point shows mainly ellipse shape with various vibrations inside the ellipse. It shows that the head moves in various amplitudes and the maximum amplitude is the outmost ellipse.

Although the size of the outmost ellipse was larger at the earlobe before removal of the inner small Buddha, it became almost similar to each point after removal. It can be understood that the fixing in the horizontal plane of the head has a certain level of flexibility and the fixing is not so differ from the measured points.

On the other hand, the locus projected at the elevation or side plane is quite differ between the three points at back of the head and the three points at the jaw and the earlobe. The vibration at back of the head draws a locus as constricted vertical motion and a forward-and-backward and a left-and-right motions seem to draw a locus of rocking vibration mainly consisted of the vibration of the body and the head, respectively. Both a back-and-forth vibration and a left-and-right vibration of the jaw and the earlobe draw a large ellipse locus predominating vertical motion.

A load is differ about 155 kg before and after removal of the inner small Buddha and other deposits. Microtremor at the jaw and the earlobe was measured before and after removal, and the locus of microtremor after removal is drawn in light color. This shows that the vibration after removal, decreasing the load about 155 kg from on the jaw, becomes not only significantly smaller amplitude but also smaller scattering. Right side vibrates obviously larger before removal and it

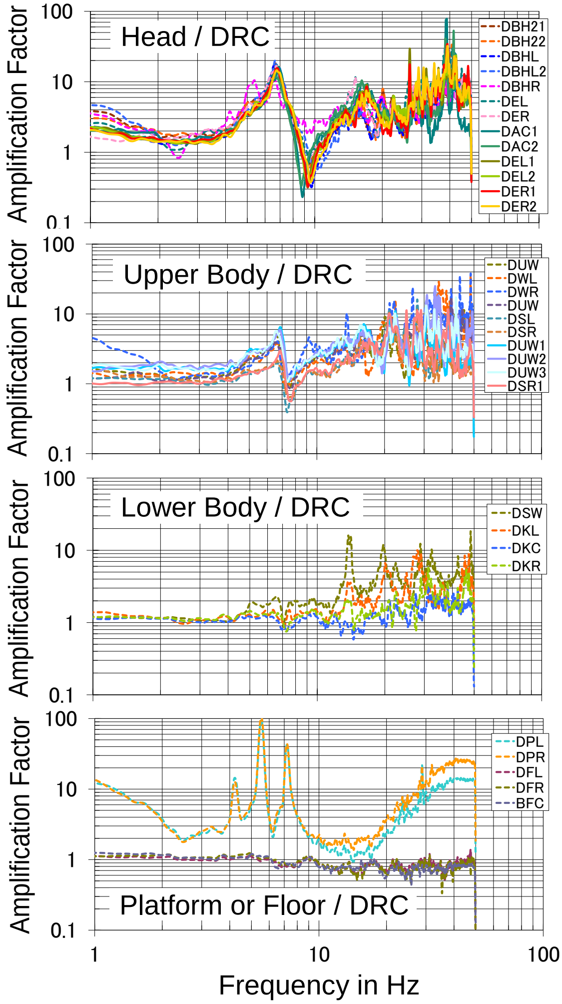


Figure 15. *Spectral Ratios against DRC Spectrum for X-component*

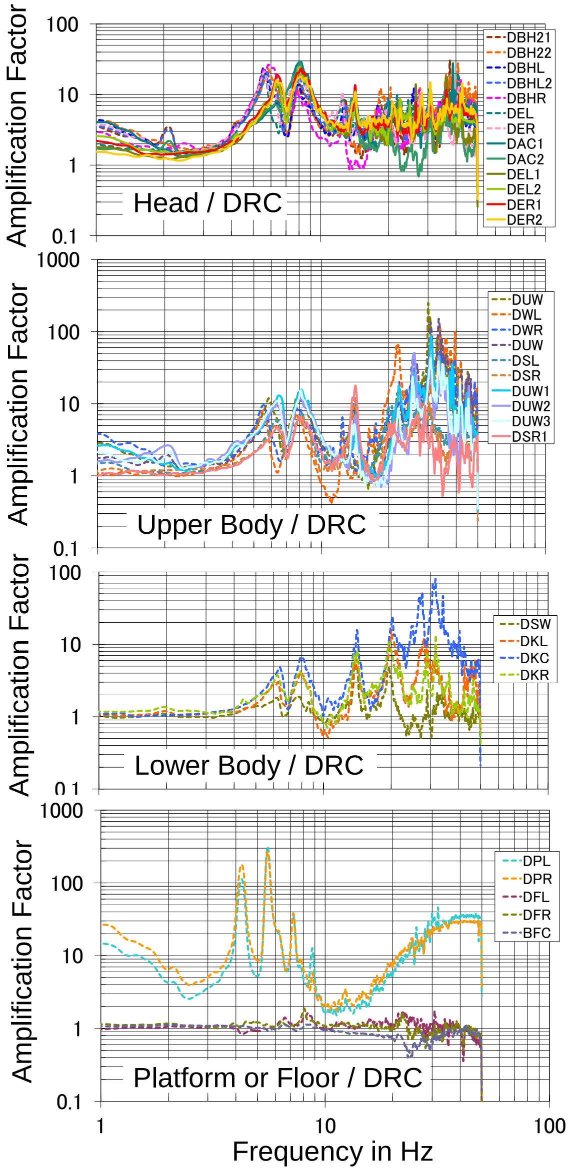


Figure 16. *Spectral Ratios against DRC Spectrum for Y-component*

seems that there becomes a little difference between right side and left side vibration after removal. It is not apparent how the vibration at back of the head changed after removal because the measurement was carried out only at the jaw and the earlobe after removal.

This apparent change of the characteristics is estimated roughly from overlapped one-minute long amplitude fluctuating in time, and this is considered in detail resolving into each frequency in the next section.

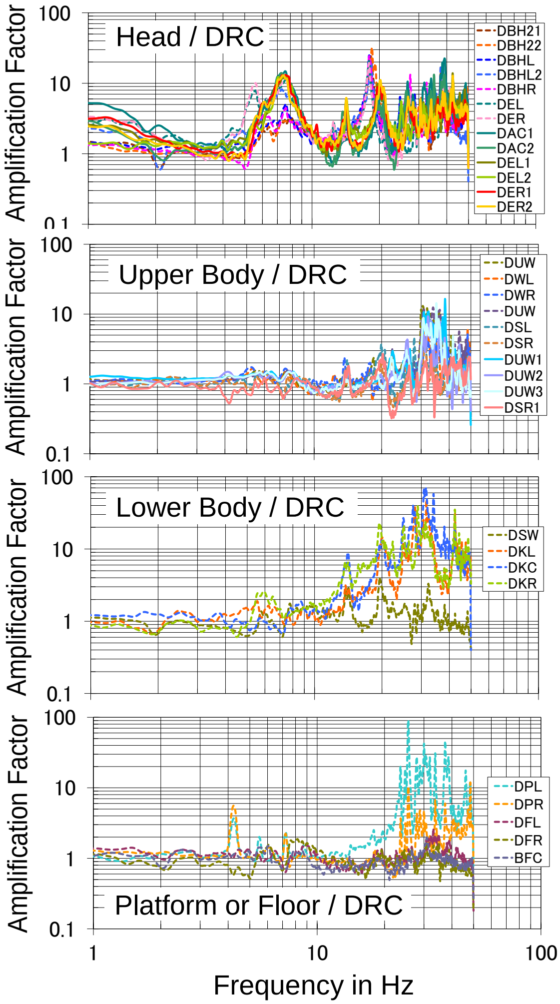


Figure 17. *Spectral Ratios against DRC Spectrum for Z-component*

4.2 Result of the frequency analysis

Figure 15 to Figure 17 show the result of the transfer function analysis of the microtremor measured at each point as standardized spectral ratio with the point DRC, separated in the head, in the upper body, in the lower body, on the floor and on the platform. These figures show the measured spectra in dotted and solid line before and after removal of the inner small Buddha and other deposits, respectively. This shows that each points at the body of the Buddha has slightly differ vibration peak for each other. The vibration characteristics of the head and the body have big difference for each other.

The vibration less than 10 Hz predominates only at the head and that over 20 Hz shows many peaks predominating at both the body and the head. It represents the high rigidity with corresponding that the body and the head is collective entity consisted of many members, and it indicates that the joint between the body and the head is relative loose.

Figure 18 is a kind of vibration mode diagram indicating the amplification factor corresponding to various predominant frequencies shown in Figures 15 to 17 with the height of the measurement point. The difference of the amplification factor at each point can be grasped by this figure.

Figure 19 shows the spectral ratio using the left side as base in case of the measurement at both left and right side and it corresponds to the situation before removal the inner little Buddha and other deposits.

Figure 20 shows the amplification spectra of earlobe based on the point DRC and the spectral ratio at the point left and right side earlobe based on the left side for before and after the removal.

Hereinafter, the frequency characteristics of the Great Buddha are considered for each vibration component referring these figures.

4.2.1 Left and right direction (X-component)

In case of left and right direction, each points at the head, the upper body, the lower body, the floor and the platform show different characteristics.

There are six measurement points in the head and all the points shows same characteristics at least less than 10 Hz. It means that the head behaves monolithically. The predominant frequency is about 6.7

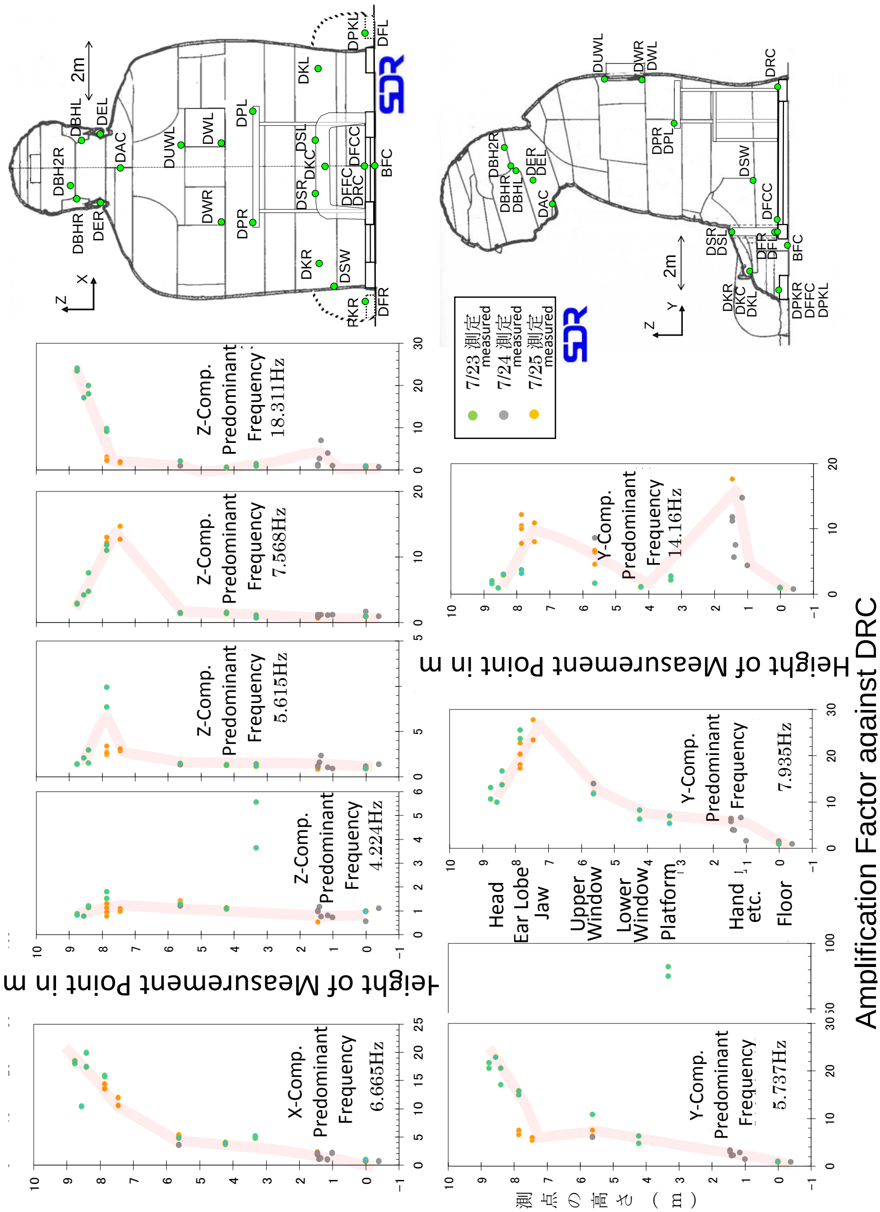


Figure 18. *Vibration modes of the Great Buddha at Kamakura*

Hz with amplification factor more than 10. It is considered as resonance combined the head and the upper body motion shown in Figure 18, and the predominant frequency was not so changed by decreasing the weight of 155 kg from the jaw.

At that time the amplitude at the body is considerably smaller than that at the head. Therefore the body is assumed as rigid and setting Kh as the spring constant of horizontal spring connecting the body and the head, the mass relating to the vibration M and the decreased mass m, the estimation of Kh and M is attempted. When the predominant frequencies before and after decreasing the weight are f and f', they can be expressed as follows.

$$(2\pi f)^2 = Kh/(M+m)$$
$$(2\pi f')^2 = Kh/M$$

$$(f'/f)^2 = (M+m)/M = 1 + m/M$$
$$\therefore\ M = \frac{m}{(f'/f)^2 - 1} \tag{2}$$

If the frequency was changed as same level of the minimum dissolution about 0.0244 Hz from 6.690 Hz although the change of the frequency can not be recognized by decreasing the load, it is possible to estimate the mass relating to this vibration as follows.

$$M \fallingdotseq 21.2 \text{ tons}$$

This is almost same level of the estimated mass of the head, 20 tons. It also suggests that this is the vibration of entire head part. Here the spring constant of connection spring Kh is estimated as follows.

$$Kh = (2\pi f)^2 M \fallingdotseq 37.7 \text{ MN/m} = 38.5 \text{ ton/cm}$$

Although this result coincides with estimation from the frequency f Hz using estimated mass of the head and suggests the hypothesis used in this estimation is proper, the detail will be examined hereafter.

In addition, a number of peaks over 10 Hz can be recognized at the body. These high frequencies seem to reflect the vibration characteristics of the parts of the body, and there are basically only high frequencies at the lower body.

All the points at the floor show almost same vibration characteristics to the basing point and it suggests high rigidity of the floor.

There are three predominant frequencies, 4.2 Hz, 5.6 Hz and 7.2 Hz at the platform. The amplification factors are roughly 15, 75 and 45, and that corresponding to 5.6 Hz is the largest.

The predominant frequency of each part of the left and right component has not changed after decreasing the load at least less than 10 Hz.

4.2.2 Back and forth direction (Y-component)

In case of backand forth direction, there are two significant peaks less than 10 Hz except at the floor and the platform. Although the vibration around 8.0 Hz has changed little by decreasing the load from the jaw, that around 5.7 Hz has shifted to around 6.4 Hz by decreasing the load. The vibration modes of them at the head are distinguishing.

The amplification factor after shifting to 6.4 Hz from 5.7 Hz by decreasing the load is relative small as 5.5 at the jaw, but it becomes larger as around 20 at back of the head.

On the other hand, the amplification factor corresponding to the vibration around 8.0 Hz is increased more than 20 excited by the body at the jaw, but it becomes about 10 at back of the head smaller than that of the upper part of the body at the back side.

This means that although these two frequencies predominate at the head, the one around 5.7 Hz shifted to around 6.4 Hz by removal the load and make the part back of the head vibrate largely, and the other one around 8.0 Hz has changed little by decreasing the load and make the jaw vibrate largely. Because the vibration around 6 Hz is responsive to the variation in weight of the jaw, this vibration seems to relate to only some portion of the head. Whereas, the vibration around 8 Hz is resonance of the body and it is estimated that the vibration is little affected by the change of the weight of the jaw because the head vibrates as dragged by this motion.

Also the vibration over 10 Hz observed at the upper body is estimated as the localized motion at each portion.

4.2.3 Up and down direction (Z-component)

In case of up and down direction, the vibration less than 10 Hz predominates only at the head and that over 15 Hz predominates at the body. The amplification factor distributes under 15 for the vibration less than 10 Hz at the head, and the amplitude is smaller than that of the horizontal motion.

Significant peaks for the head appear around 5.6 Hz, 7.6 Hz and 18.3 Hz. The peak at 5.6 Hz can be seen only at the point DER or DEL at the base of the earlobe before removal and its amplification is about 8. The body moves little by the vibration at 7.6 Hz and the amplification factor becomes larger from back of the head to the jaw and exceeds 10. Contrary to this, the amplification factor of the vibration around 18.3 Hz exceeds 20 toward to back of the head.

The vertical motion at 7.6 Hz has changed little after removal and is confirmed to have high correlation with the vibration of back and forth direction. The vibration at 5.6 Hz and 18.3 Hz has shifted to higher frequency as around 6 Hz and 20 Hz after removal. The vibration at 18.3 Hz is a motion that the head moves up and down dominantly and the motion at the body is considerably small without that behind the knee.

Therefore assuming the body as rigid and the weight of the head as 20 tons same as a back and forth motion, the spring constant of connecting spring for vertical motion to the head Kv can be estimated as follows.

$$Kv = (2\pi f)^2 (M + m) \fallingdotseq 264 \text{ MN/m} = 269 \text{ ton/cm}$$

This is 7 times more than the spring constant Kh of horizontal spring, and the properness of this result will be validated hereafter.

4.2.4 Measurement points corresponding between left and right side

Figure 19 shows the spectral ratio referenced by the left side point in case of the measurement corresponding between left and right side. This figure shows a situation before removal of the inner small

Buddha and other deposits. And Figure 20 shows the similar spectral ratio of the measurement at the earlobe before and after the removal and additionally shows the amplification spectra against the point DRC. Here the consideration is advanced noticing the frequency range displaying large amplification.

With Figure 19, L/R ratio of vertical motion shows similar shape for the points DBHL and DBHR at back of the head and the points DEL and DER at the earlobe and slightly different shape for the points DKL and DKR at the knee. And the ratio becomes about 1 at frequency range less than 20 Hz same as the points DSL and DSR at the supporting frame work, which means that the motion is almost same for both left and right side. It is estimated that the supporting

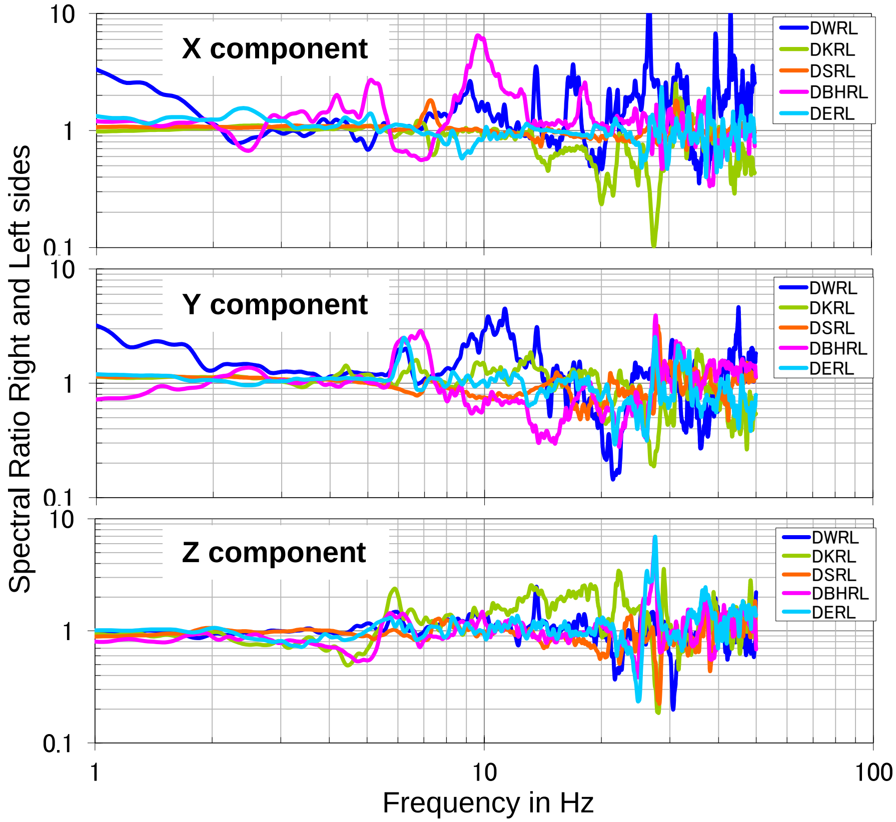


Figure 19. *Spectral ratio of right and left sides (before removal of weight)*

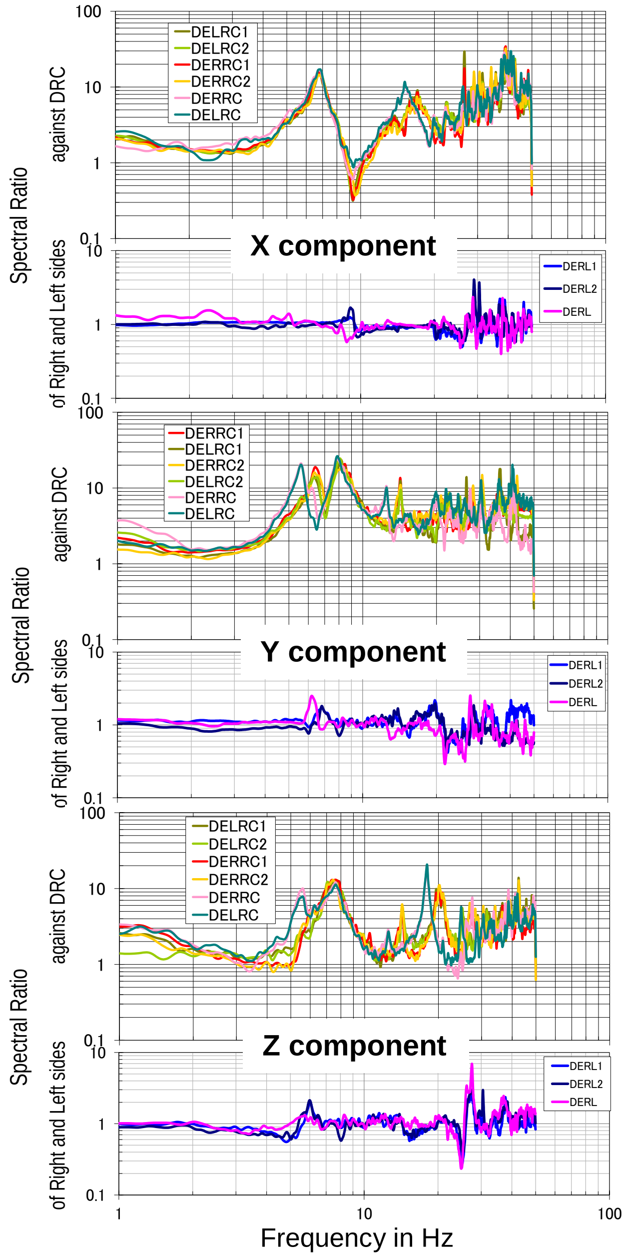


Figure 20. *Spectral ratios between earlobes and DRC,and spectral ratio between right and left of earlobe (before and after removal of weight)*

situation of the head on the vertical direction is mostly same for both left and right side.

The left and right motion is differing little from the points at left and right side at the earlobe or the points DSL and DSR at the supporting frame work. However, R/L ratio is about 0.6 at around 6.7 Hz, which estimated to be the resonance of the head, and it means that the left side motion at back of the head is 1.7 times larger than the right side motion. Also in case of back and forth motion, the left side motion is rather large at around 8 Hz as the predominating frequency range of it. These phenomena are noticed relating to the fact that the connecting sitution to the body is differing between the left and right sides.

Hereafter, the authors will consider this situation in detail because the difference of the vibration characteristics for left and right side relate to the connecting situation of casting.

4.2.5 For a further understanding

Finally, an animation is developed as an attempt to grasp visually the total vibration characteristics of whole the Great Buddha with projecting not only the vibration mode of each component but also the vibration locus for each frequency to XY, YZ and XY plane [6]. This animation draws a vibration locus considering the degree of correlation for the vibration direction component at each plane. Therefore, note that the movement at each plane is independent for each other and this animation does not draw one motion projecting to each plane. Also because the locus on this animation is drawn back to the measured point after one period, the drawing direction of the locus can be confirmed.

As mentioned above, it is confirmed from this animation that the vibration less than 10 Hz mainly makes the head move largely and various frequencies are appeared as a large motion of various portion continuously. Although this Great Buddha is bilaterally symmetric seating statue, the vibration characteristics are slightly differ between right and left sides and it is estimated to reflect the characteristics of this Great Buddha with a lot of connection.

The change of the characteristics caused by removal of the load on the jaw is unexpectedly large. However it is expected to be able to grasp precisely the local situation with grasping the vibration characteristics by changing the load actively. Hereafter, the authors would like to continue research in detail keeping in mind these points.

5. Concluding remarks

It is quite important for the Great Buddha of Kamakura to understand the vibration characteristics of the head because it relates to integrity of the connection between the body and the head.

The report of a major repair in Showa era was done in 1960 says that the problem of the connection exists mainly at back of neck and there is little problem from the chest to front of neck. And it also says that although the portion back of neck at right side (west side) was almost succeeded to connect at the time of casting, that at left side (east side) was almost failed to connect and it was repaired by tinkering or other technique after casting.

As a result of microtremor measurement at some points in the head, the vibration less than 10 Hz predominates at the head. Also it is cleared that the vibration over 20 Hz predominates at the body and the predominant frequency of the vibration related to the connection between the body and the head is lower frequency less than 10 Hz.

The weight of the head has been estimated about 20 tons and it is remarkable that the vibration characteristics is significantly affected by change of the load about 155 kg with removal of the inner small Buddha and other deposits. It suggests that the welding connection moves with a certain level of degrees of freedom but the head vibrates as a unit. Therefore, it pointed out the necessity to consider carefully the connecting situation at each portion in the head. Hereafter it is expected to carry out more detailed measurement with increasing the number of measurement points around the connection between the head and the body to grasp the dynamic situation. It seems that it is necessary to take a proper countermeasure based on the result of this detailed measurement.

The frequency of the horizontal motion at the platform is 4.2 Hz, 5.6 Hz and 7.2 Hz, and these vibrations are torsional vibration except that at 4.2 H. So, sway vibration at 4.2 Hz of back and forth direction is estimated to predominate during earthquake motion. In this time the amplification factor becomes large value 175 at the right side.

The gap between the stage and the body of the Great Buddha is about 2 cm and the amplitude of the motion at the stage might be estimated about 2 cm in maximum if the earthquake motion reaches 8 Gal or Japanese Seismic Intensity 3 at the floor of the Great Buddha, assuming that the amplification factor is kept during the earthquake motion. The earthquake motion larger than this has a possibility of collision against the body of the Great Buddha. It seems that it is necessary to take a countermeasure for conservation of the Great Buddha.

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