

# Development of Double Wishbone Type Front Suspension for 2018 Gold Wing

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## ABSTRACT

In developing the front suspension system for 6th generation 2018 Gold Wing GL1800, we aimed to realize both agile handling and high stability at the same time, and a comfortable and high quality riding experience. To this end, we developed a Honda original double wishbone type suspension system for motorcycles. By devising the arm layout, the stroke trajectory of the front axle was set in the vertical direction, and the amount of rearward movement of the tire was reduced. This made it possible to allow forward shifting of the engine position, which in turn increases the front divided load, and we were able to realize both agile handling and high stability at the same time. In addition, by using needle bearings for all pivots and at the same time having a structure in which lateral force does not act on the cushion, the sliding resistance was able to be reduced as compared with the telescopic type suspension. As a result of all these enhancements, the vertical acceleration of sprung mass was reduced by about 30% compared with the previous model in traveling roads such as an uneven road, contributing to the realization of a high quality and comfortable riding experience. Furthermore, in this system, the handlebar pivot axis is offset backward from the wheel steering pivot axis, and tie rods are used to connect between the pivots. This mechanism effectively shortened the length of the handlebars and enhanced operability in situations close to full steering.

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## 1. Introduction

The 2018 Gold Wing GL1800 has undergone the first full model changeover, in 17 years since the launch of the 5th generation model in 2001. We aimed to develop “the motorcycle with the most enjoyable maneuverability throughout all the models appeared in the chronicle of the Gold Wing.”, by providing the feeling of high quality in the maneuverability, running performance, and comfort. To achieve this, the following two items were set as the goal.

- Realization of packaging to enable both agile handling and high stability
- Realization of comfortable and high quality riding comfort

To realize both agile handling and high stability, it was found necessary to move the engine as well as the riding position forward to increase the front divided load. Furthermore, to achieve a comfortable and high quality ride, it was required to develop a suspension system with low sliding resistance and high rigidity. Since the first generation of Gold Wing, we have been using telescopic type suspension for the front suspension system. However, to achieve the high-level goal of this development, a

completely new suspension system was required being apart from the conventional structure. As a result of comparing various types of suspension systems, the front suspension which is most suitable for this model was a double wishbone type suspension system.

This paper introduces the double wishbone type front suspension system newly developed for the 6th generation Gold Wing GL1800.

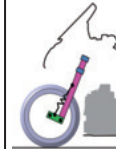
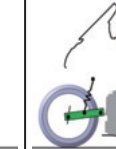
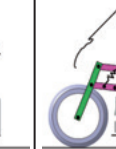
## 2. Selecting the Type of Suspension

In selecting the type of suspension, we considered various factors besides the required performances including the external appearance suitable to the status of the new grand tourer as well as mounting capability of highly advanced systems. **Figure 1** shows the result of the comparative study. From the result, it became clear that the double wishbone type suspension, which adopts the needle bearing for the pivot which is advantageous for reduction of sliding resistance and high rigidity, is the most effective in achieving the goal of this model.

On the other hand, in the previous model, while a telescopic type suspension was adopted as a front

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| Type           |                                   | Telescopic                                                                        |                                                                                   | Bottom link                                                                       |                                                                                   | Arm link                                                                           |                                                                                     |
|----------------|-----------------------------------|-----------------------------------------------------------------------------------|-----------------------------------------------------------------------------------|-----------------------------------------------------------------------------------|-----------------------------------------------------------------------------------|------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------|
|                |                                   | Upright<br>(previous model)                                                       | Inverted                                                                          | Leading                                                                           | Trailing                                                                          | Hub steer                                                                          | Bearing pivot<br>DWB* link                                                          |
|                |                                   |  |  |  |  |  |  |
| Performance    | Shift engine position forward     | BASE                                                                              | ≡                                                                                 | ≡                                                                                 | ≡                                                                                 | +                                                                                  | +                                                                                   |
|                | Reduce sliding resistance         | BASE                                                                              | ≡                                                                                 | +                                                                                 | +                                                                                 | +                                                                                  | ++                                                                                  |
|                | Increase stiffness                | BASE                                                                              | +                                                                                 | -                                                                                 | -                                                                                 | -                                                                                  | +                                                                                   |
|                | Reduce steering moment of inertia | BASE                                                                              | ≡                                                                                 | -                                                                                 | -                                                                                 | +                                                                                  | +                                                                                   |
|                | Weight                            | BASE                                                                              | ≡                                                                                 | -                                                                                 | -                                                                                 | -                                                                                  | -                                                                                   |
| Market-ability | Innovativeness                    | BASE                                                                              | ≡                                                                                 | ≡                                                                                 | ≡                                                                                 | +                                                                                  | +                                                                                   |
|                | Appearance                        | BASE                                                                              | ≡                                                                                 | ≡                                                                                 | ≡                                                                                 | +                                                                                  | +                                                                                   |

Change from base model

Comparable:



Superior:



Inferior:



\*DWB: Double wishbone type

Fig. 1 Comparison of suspension types

suspension, we aimed at compatibility between relaxed position like grand tourer and slow speed maneuverability. For this reason, the forward and backward offset amount between the handle grips and steering was long, and the width between the grips was widened. Therefore, with this structure, the amount of movement of the grip end during the steering increases. In applying this handle structure to newly developing model, the issue was that one grip point becomes very close to the rider's side and the other grip point becomes very far at full steering. To solve the issue, we devised a new system in which the handlebar pivot axis and the wheel steering pivot axis are made separate axes, the handlebar pivot axis is offset rearward, and tie-rods are used to connect between the pivots. Based on the above idea, we have selected a double wishbone type suspension system using a needle bearing for all pivots, with the handlebar pivot axis and the wheel steering pivot axis are separate axes in newly developing model.

### 3. Suspension Structure

Double wishbone type suspensions are fairly popular in four wheel vehicles. As this type of suspension can realize superb riding comfort and high controllability, it is popularly used for high-class automobiles, sports cars, and F1 racing machines. For example, Honda is using it for the NSX, the Legend, and other models (Fig. 2)<sup>(1)</sup>.

The specific features of double wishbone type suspensions are listed below:

- Smooth operation due to no side force on the cushion unit;
- High structural rigidity with upper and lower arms to support the wheel; and
- High freedom of alignment design to determine the caster angle and camber angle.



Fig. 2 Double wishbone type suspension for automobiles

While inheriting these features, the double wishbone system was arranged for the newly developing model by changing the wheel to arm mounting angle by 90 degrees to create a unique configuration for use on a motorcycle. The structure has two arms to support the front fork and fork holder that move up and down. Figure 3 illustrates the structure of the suspension. This system consists of three portions, i.e., wheel steering portion, shock absorbing portion, and handlebar pivot portion.

The wheel steering portion consists of the front fork and the steering arm coupled to it. These are aluminum die casted parts of thin-walled hollow structure. By making it an integral unit to support the wheel from both sides, a highly rigid, light-weight structure was created. Unlike conventional telescopic forks, this structure does not have shock absorbers. As a result, the rotational moment of inertia of the steering system was reduced by more than 40% from the previous model.

The shock absorber portion is structured to support the fork holder corresponding to a steering head tube at the forefront of a conventional motorcycle frame by the upper and lower arms, and a cushion unit is attached to the lower arm. The point of this structure is that no bending force is applied on the cushion unit. Also, while it is generally the case with four wheel vehicles that ball joints or rubber bushings are used for the joints of links, all pivots of this structure use needle bearings and four-point contact ball bearings, it is structured to obtain high rigidity and smooth rotation without play. Furthermore, by properly arranging

the arms, the system is designed to move the front wheel vertically against the ground, or to make the stroke trajectory of the wheel vertical, to reduce the backward movement of the front tire by 24 mm from the previous model (Fig. 4).

The handlebar pivot portion consists of the steering bridge, handlebars, and tie rods. By connecting sprung mass (i.e. the handlebar pivot portion) and unsprung mass (i.e. the wheel steering portion and the shock absorber portion) with special tie rods which were reduced play, this structure provides high quality riding comfort as well as the feel of direct maneuverability.

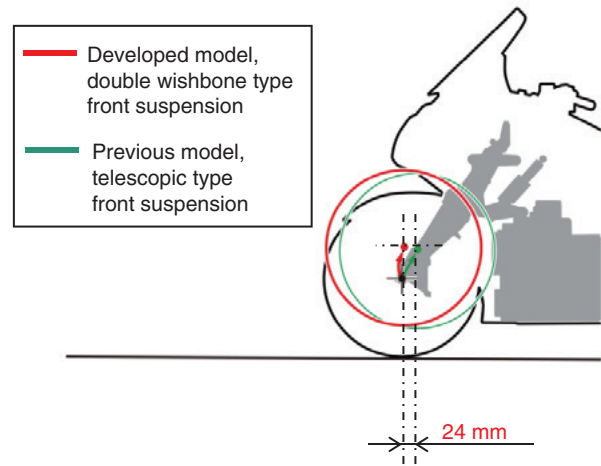


Fig. 4 Comparison of front tire stroke trajectories

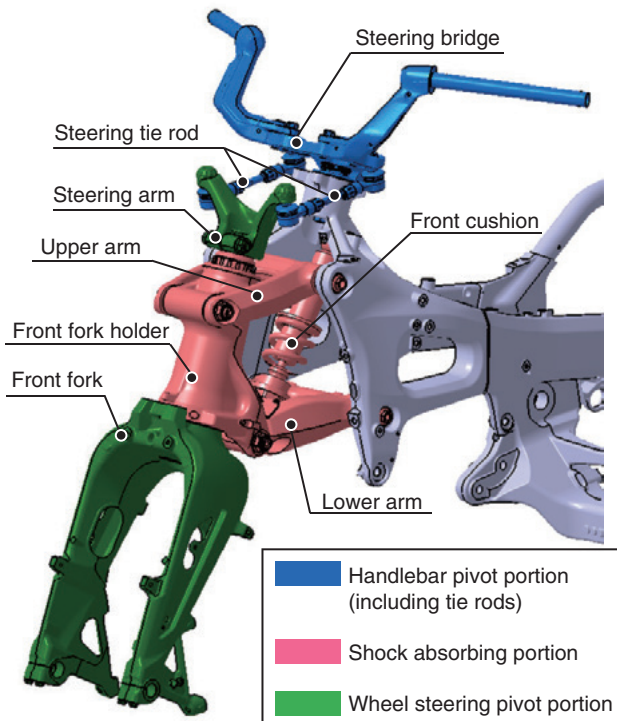


Fig. 3 Front suspension of 2018 Gold Wing

#### 4. Packaging to Enable Both Agile Handling and High Stability

As already mentioned, because the backward movement of the front wheel was reduced by 24 mm, we were able to shift the engine mounting position forward. By doing so, the front divided load ratio was increased to 46.5% in DCT model compared to 44.9% of the previous model. In addition, while maintaining the living space of the rider and the passenger, it was possible to shift the riding position forward by 36 mm together with the compactness of the engine (Fig. 5). As a result, the aim of enhanced maneuverability and body size reduction were achieved as intended. Furthermore, by making the distance between the wind screen and the rider closer, we were able to use a smaller wind screen to gain the same or better wind protection effect compared to the previous model.

While the conventional telescopic type suspension requires some space to allow the movement at the top of the right and left forks for the steering, the new system does not require such a space because only the wheel

steering pivot is to be steered. So, the width of the front cowl can be reduced. As a result, together with the size reduction of the side radiator, we were able to reduce the front cowl width by about 100 mm around the wheel steering pivot (Fig. 6). In addition, by separating the handlebar pivot from the wheel steering pivot, we were able to lower the height of the instrument panel above the wheel, contributing to lowering the center of gravity of the motorcycle. Furthermore, being helped by the increased freedom of design to position the handlebar, we were able to increase the clearance between the rider and the handlebar in the fully steered position by 90 mm for enhanced operability (Fig. 7).

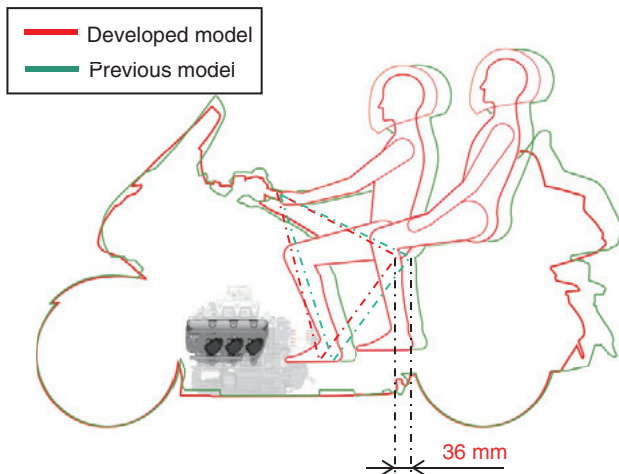


Fig. 5 Engine location and riding position

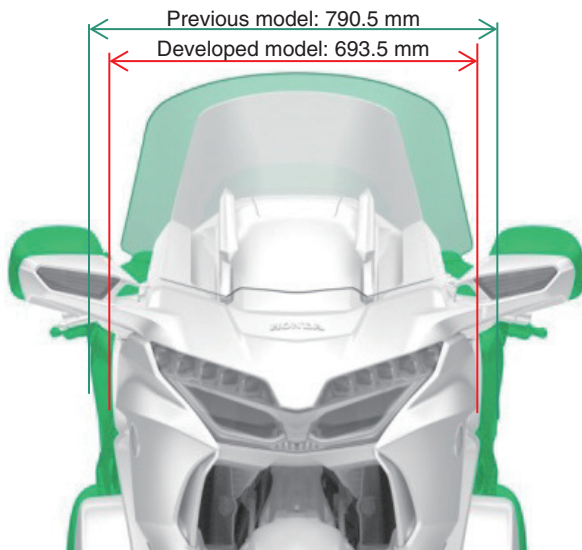


Fig. 6 Comparison of front cowl widths

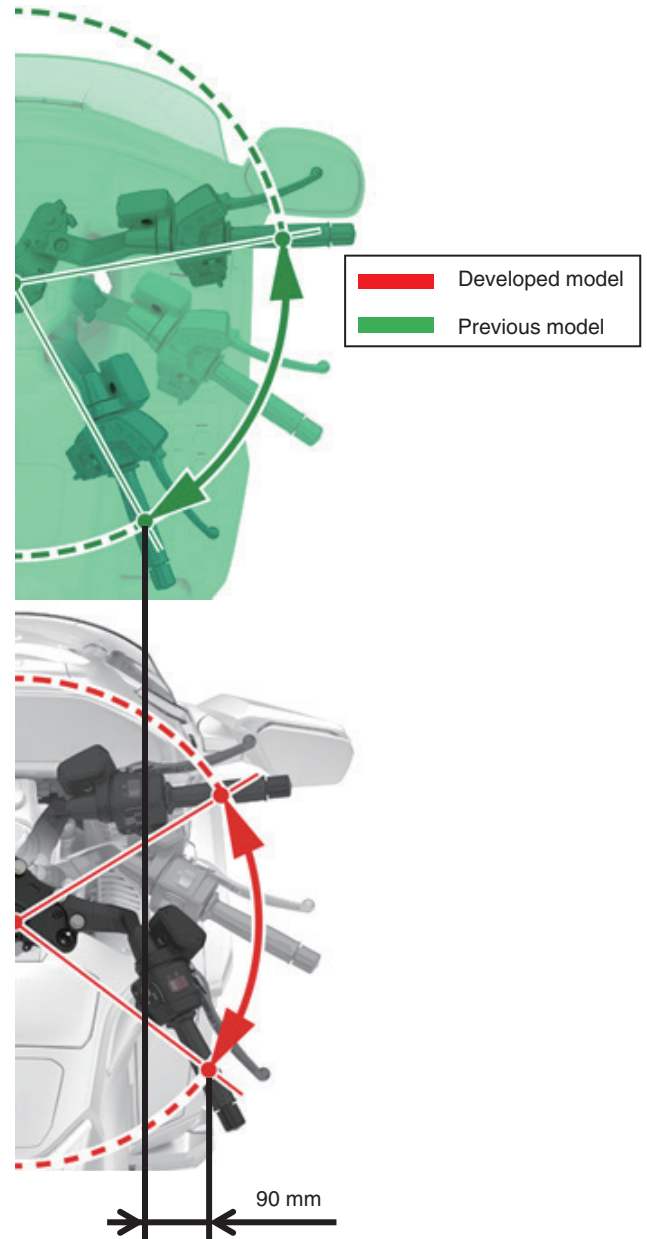


Fig. 7 Comparison of handle grip positions at full steering

## 5. Realization of High Quality Riding Comfort

To check the performance achieved of the double wishbone type front suspension described in Section 3, we performed actual running measurement test. We measured the vertical acceleration of the sprung mass by running the vehicle at 60 km/h on continuous steps of 10 mm - 20 mm high. Figure 8 shows the results. From the figure, we can see that the peak acceleration level is lower than that of the previous model. Next, Fig. 9 shows the average values of 10 samples of peak acceleration. From the comparison, we

can see that the vertical acceleration of the sprung mass is reduced by 30% from the previous model.

Then, to verify the mechanism of the performance enhancement, we measured the acceleration of both sprung mass and unsprung mass and the pitch angular velocity of the body by running the vehicle at 100 km/h on a single step of 20 mm high. Figure 10 shows the time-series data of the vertical acceleration of the sprung mass. The developed model shows lower peak acceleration and quicker convergence than the previous model. Figure 11 shows the time-series data of the pitching rate. We can see that the developed model shows the level of higher frequency components is lower and the overall behavior is gentle as compared to the previous model. It can be inferred

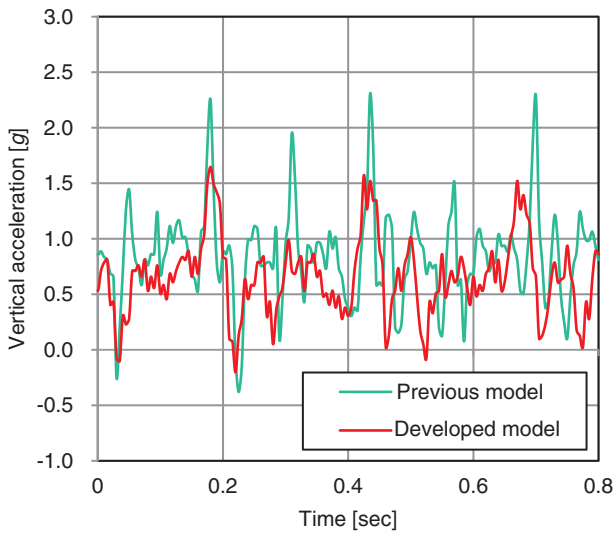


Fig. 8 Sprung mass vertical acceleration when running on continuous steps

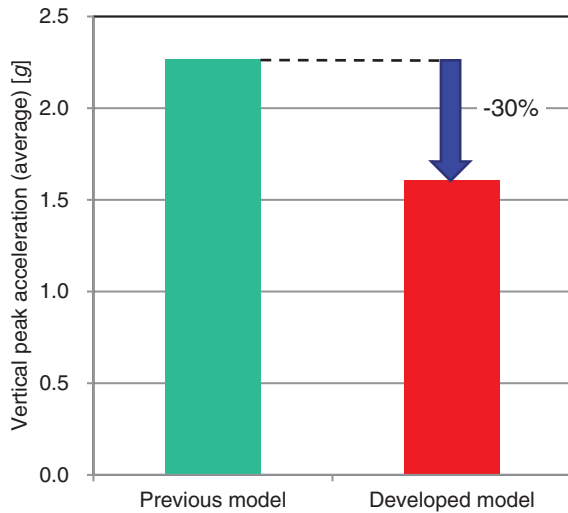


Fig. 9 Average of sprung mass peak acceleration when running on continuous steps

that these characteristics are connected to the high quality feeling. Furthermore, we performed spectrum analysis on the longitudinal acceleration of the unsprung mass. The result is shown in Fig. 12. In the case of the previous model with telescopic type front suspension, we see peaks at

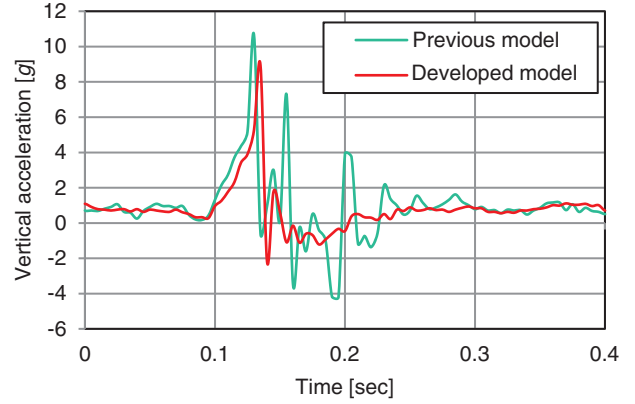


Fig. 10 Vertical acceleration of sprung mass when passing through step (h=20 mm)

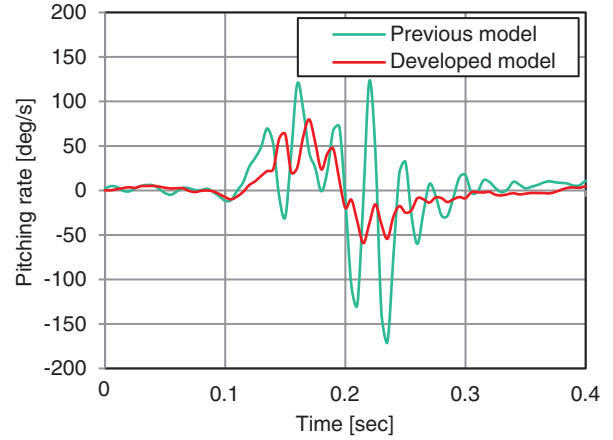


Fig. 11 Pitching rate when passing through step (h=20 mm)

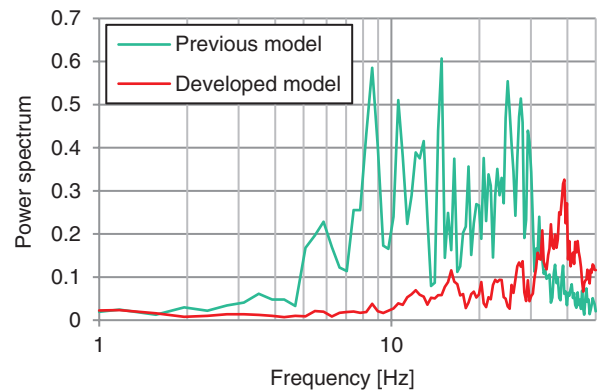


Fig. 12 Power spectrum of longitudinal acceleration of unsprung mass when passing through step (h=20 mm)

around 10 Hz and 25 Hz. These peaks are considered to be showing the longitudinal vibration caused by the bending motion of the front fork. On the other hand, the peak spectrum for the new model is higher, i.e., at around 40 Hz, and it shows that the bending stiffness of the suspension is higher and thus longitudinal vibration is minimized.

From these results, we can see that the suspension system of the developed model can operate smoothly while absorbing the inputs from the road surface, and thus it provides a high quality riding comfort.

## 6. Conclusions

For realization of packaging to enable both agile handling and high stability, and realization of comfortable and high quality riding comfort, we developed a new front suspension. We adopted a double wishbone type suspension for motorcycles with a unique structure separating the handlebar pivot axis from the wheel steering pivot axis. With this suspension structure, it became possible to change the tire stroke trajectory and to mount the engine forward. As a result, the front divided load increased, realizing both agile handling and high stability at the same time. By adopting this structure with reduced sliding resistance by adopting needle bearing for the pivot of each part of the link, the acceleration level of the sprung mass was reduced by 30%, the convergence of pitch motion was enhanced, and a high-quality riding comfort was achieved.

## Reference

- (1) <http://www.honda.co.jp/NSX/webcatalog/performance/driving/>

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