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Motorcycle Engineering

Analysis of Geometric Data and Schematic Diagram

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1. Introduction

This technical report analyses the dynamic behaviour, geometry and handling of two motorcycles. A Kawasaki ZX750-J 1991 and an Aprilla RS250 1996, were subjected to direct measurement and Excel spreadsheet-based analysis using data measured within a workshop setting and Excel formulae. Comparative to that of two modern motorcycles, a Yamaha R7 2022 and a Suzuki GSX-8R 2024, utilising data taken from images, references and figures. These modern motorcycles were specifically selected to emphasise the difference in era, taking into consideration the age disparity between the two couples. This was done to isolate the older motorcycles and preserve clarity when comparing differing engineering methodologies.

1.1 Methodologies

Pertaining to the ZX750-J and RS250, physical measurements were taken before Excel data was used to evaluate static and rider-loaded wheel weights, wheelbase, rake, trail, Centre of Gravity (CoG) height and lengthways position, gearbox ratios, engine RPM, and power output. CoG was derived from supporting the motorcycle at an angle so that its front or rear wheel could be measured in a controlled manner, generating wheel-load changes under controlled vertical displacement. Dynamic weight transfer during acceleration and braking was calculated using rigid body-mechanics. Gear ratios and rear-wheel diameter were combined with aerodynamic drag data to determine realistic top-speed limits, with the RS250 set at 0.55 and the ZX750-J set at 0.6 for a realistic coefficient of drag with a rider in a tucked position . The R7 and GSX-8R were analysed using MotoSPEC geometry data, including wheelbase, steering head angles, trail, swingarm pivot coordinates and suspension linkage geometry. This allowed for the analysis of performance data and comparison throughout the report.

2. Interpretation of Geometry, Handling, Gear ratios and Speed Characteristics: Kawasaki ZX750R-J & Aprilla RS250

2.1 Weight Distribution & Centre of Gravity Positioning

Physical data taken from the workshop indicates that the ZX750-J has a longer wheelbase and rearward weight bias relative to the RS250. With and without-rider loaded wheel weights show that the ZX750-J places more load on the rear tyre, improving traction during acceleration, as there is a consistent load being applied to the contact patch of the rear tyre during the process. In conjunction with the ZX750-J's relatively high CoG, increased pitch effects occur under throttle and braking.

The RS250 however, has a shorter wheelbase, lower CoG and more balanced weight distribution. Thus, maintaining front-end loading for more agile handling. Rake and Trail measurements show that the ZX750-J emphasises high-speed stability with less importance on cornering, while the RS250's steeper rake and shorter trail support rapid lean initiation and precise mid-cornering adjustments.

Due to the ZX750-J experiencing more pronounced rearward weight transfer under acceleration, there is less front-end authority. Therefore, braking substantially produces forward transfer by compressing the forks and enhancing steering responsiveness. In comparison, the RS250's lower CoG moderates weight transfer in both directions, preserving front-end load and predictable chassis geometry during strong acceleration and braking periods.

2.2 Cornering and Steering Behaviour

The ZX750-J exhibits slower turn-in, heavier steering, and a preference for smooth lines in sweeping corners. Mid-corner corrections require precise input due to reduced front-end load. In contrast, the RS250 demonstrates rapid lean initiation, responsive steering and minimal pitch. This allows for more confident cornering and mid-cornering adjustments. Acceleration and/or braking produces slightly more predictable geometry changes.

2.3 Gearing and Top Speed Analysis

Gearing significantly influences acceleration, engine RPM and theoretical top speed. The ZX750-J features long, high-speed gearing typical of a high torque four-cylinder engine. The calculations performed in Excel show a Top speed of roughly 240 kilometres an hour at redline. In practice the bike approaches this speed in optimal conditions, especially in a tucked position. However, aerodynamic drag increases with speed, eventually surpassing the engine's available thrust. Consequently, while the gearing allows high speeds, the ZX750-J is power-limited near its maximum.

The RS250 uses short, close-ratio gearing to keep its high-revving two-stroke engine within a narrow power band. Theoretical top speed is approximately 214km/h, but limited engine

2. Interpretation of Geometry, Handling, Gear ratios and Speed Characteristics: Kawasaki ZX750R-J & Aprilla RS250

output prevents the RS250 from reaching this velocity. Real world top-speed typically falls between 190-200 km/h. The close-ratio gearing maintains the engine in its optimal RPM range for rapid acceleration and corner exits, but drag dominates at high speed, preventing full exploitation of the gearing. Thus, the RS250 is gearing-optimised for acceleration rather than maximum top speed, whereas the ZX750-J's gearing suits straights and higher engine output.

2.4 Recommendations for Handling Improvements

Based on the Excel data produced and continued analysis of both the ZX750-J's and RS250's dynamics, the ZX750-J could benefit from slightly more forward weight distribution so that the front-end feels more stable, particularly during corner entry. This can be done by either repositioning the rider's seat more forward, or more drastically, shifting the engine itself more forward. moderate adjustments to rake and trail with suspension tuning to reduce the aggressive pitch under acceleration and braking, although this should only be carried out in increments to ensure the primary characteristics of the ZX750-J remain intact. Another solid adjustment that would maintain the ZX750-J's riding attitude, according to (Paredes, 2024), would be to add a steering dampener. In a street-based setting, steering dampeners are useful if sudden changes in road quality cause an uneven road surface. This could lead to unwanted vibrations and jolts through the suspension and subsequently handlebars. Outlined by (Jackson, 2025), the death wobble, although rare, is more common in motorcycles with less even weight distribution and a lighter feeling front-end. This detail proves that the ZX750-J would benefit greatly from a steering dampener in the long run, especially when considering a two-hour ride across hundreds of miles of potentially uneven road surfaces.

The RS250 could see improvements from minor wheelbase extension for enhanced high-speed stability, especially in fast corners. This also will reduce any rear-end instability during corner exits. The wheelbase extension should be minimal to preserve the motorcycle's agility, which is essential in tighter, low-speed corners like a hairpin slight rake and trail adjustments to allow for more mid-corner stability, optimised steering responsiveness and suspension damping

refinement to manage acceleration squat. These adjustments preserve each motorcycle's design engineering while improving mid-corner control, steering precision and rider ergonomics.

Aprilla 250					
Level	With Rider		Level W/Rider Lift	Lifted W/rider	
Front Wheel (kg)	71.5	99.1	79.35	119.7	
Rear Wheel (kg)	66.95	115.45	59.05	94.85	
Wheelbase (mm)	1.35			Weight of Motorcycle	138.45
Rw rad (mm)	0.305			Rider Weight (kg)	76.6
Fw rad (mm)	0.292			Total Weight (kg)	215.05
Rav (mm)	0.295				
Stool Height (mm)	0.4			Stool Weight	5
Lifted Angle (Degree)	17.24				

Without Rider					
YcoG	0.543	Load Transfer Front (% 51.64	With Rider Front (%)	46.31	
XcoG	0.653	Load Transfer Rear (% 48.36	With Rider Rear (%)	53.69	

With Rider					
YcoG	0.712				
XcoG	0.725				

Rake (degrees)	25
Trail (mm)	0.085

Figure 1. Aprilla RS250 Geometry Data

2. Interpretation of Geometry, Handling, Gear ratios and Speed Characteristics: Kawasaki ZX750R-J & Aprilla RS250

Kawasaki ZX750 1996						
Level	With Rider	Level W/Rider Lifted	Lifted W/rider			
Front Wheel (kg)	105.85	150.4	114.85	175.7		
Rear Wheel (kg)	91.25	164.6	82.2	135.5		
					Rake	24.5
Wheelbase (mm)	1.445				Trail	0.095
Rw rad (mm)	0.303				Weight of Motorcycle	197.1
Fw rad (mm)	0.284				Rider Weight (kg)	119.5
Rav (mm)	0.435				Total Weight (kg)	316.6
Stool Height (mm)	0.4				Stool Weight	5
Lifted Angle (Degrees)	16.0703015					
Without Rider						
YcoG	0.665	Load Transfer Front (%)	53.70	With Rider Front (%)	48.0101	
XcoG	0.669	Load Transfer Rear (%)	46.30	With Rider Rear (%)	51.9899	
With Rider						
YcoG	0.896					
XcoG	0.751					

Figure 2. Kawasaki ZX750-J Geometry Data

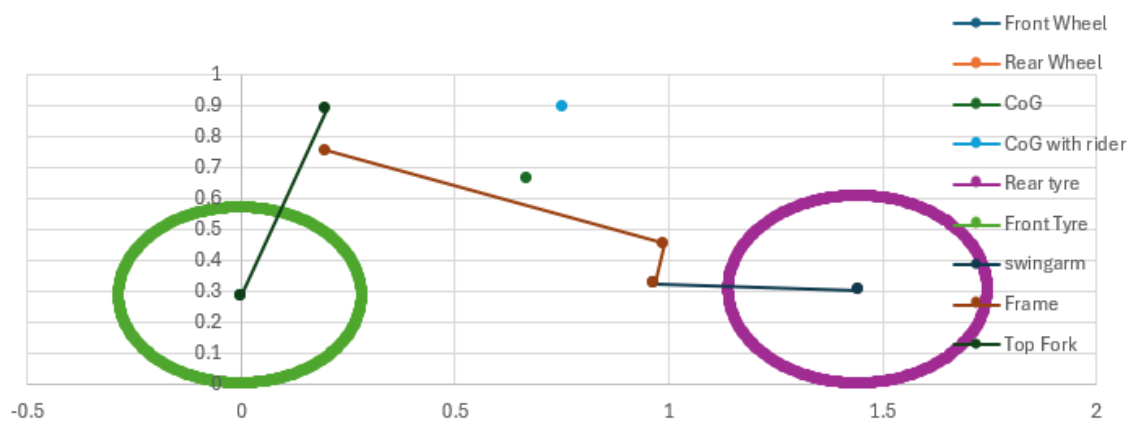


Figure 3. Kawasaki ZX750-J Schematic Diagram

Aprilla RS250

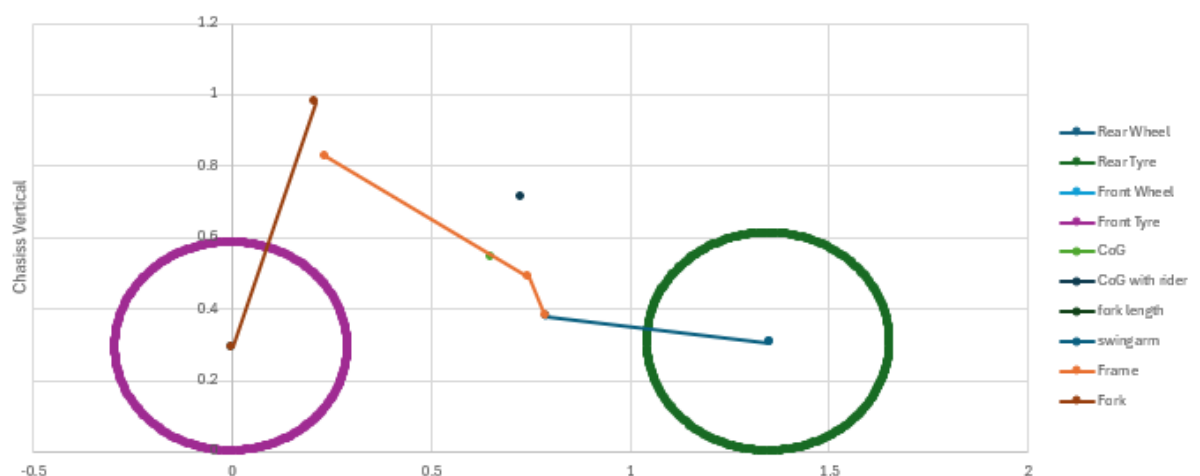


Figure 4. Aprilla RS250 Schematic Diagram

2. Interpretation of Geometry, Handling, Gear ratios and Speed Characteristics: Kawasaki ZX750R-J & Aprilla RS250

Gearbox		
Primary	56	97
FINAL	16	46
Diam	0.6298 m	
RPM	11000	

Ratios		speeds	
1st	13	38	89.70872
2nd	16	34	123.4002
3rd	21	35	157.3353
4th	21	29	189.8874
5th	23	28	215.3995
6th	24	26	242.0543

Figure 5, Kawasaki ZX750-J Gear Ratio

Gearbox		
Primary	23	59
FINAL	14	42
Diam	0.6118 m	
RPM	11900	
Ratios		speeds
1st	11	27 72.65091
2nd	16	26 109.7384
3rd	17	21 144.3583
4th	22	23 170.5717
5th	24	22 194.5363
6th	25	21 212.2916

Figure 6, Aprilla RS250 Gear Ratio

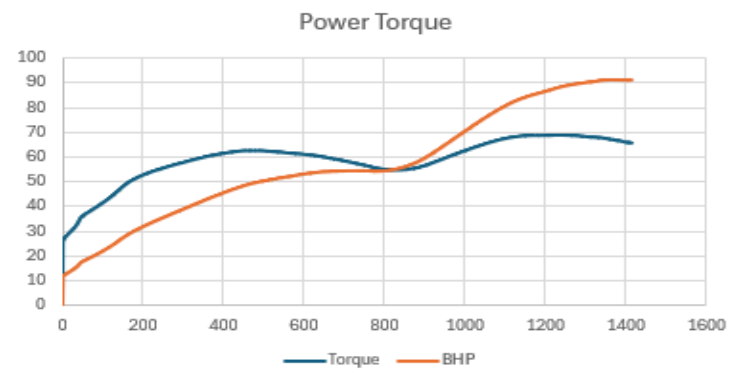


Figure 7, Kawasaki ZX750-J Power Torque Diagram

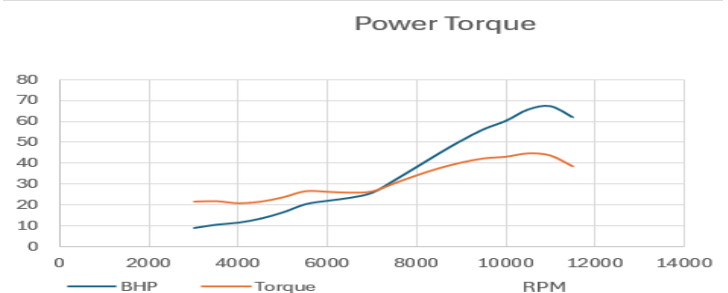


Figure 8 Aprilla RS250 Power Torque Diagram



Figure 9 Aprilla RS250 Gearing Resistance Diagram



Figure 10 Kawasaki ZX750-J Gearing Resistance Diagram

3. Interpretation of Geometry, Handling, Gear ratios and speed characteristics: Yamaha R7 (2022) & Suzuki GSX-8R (2024)

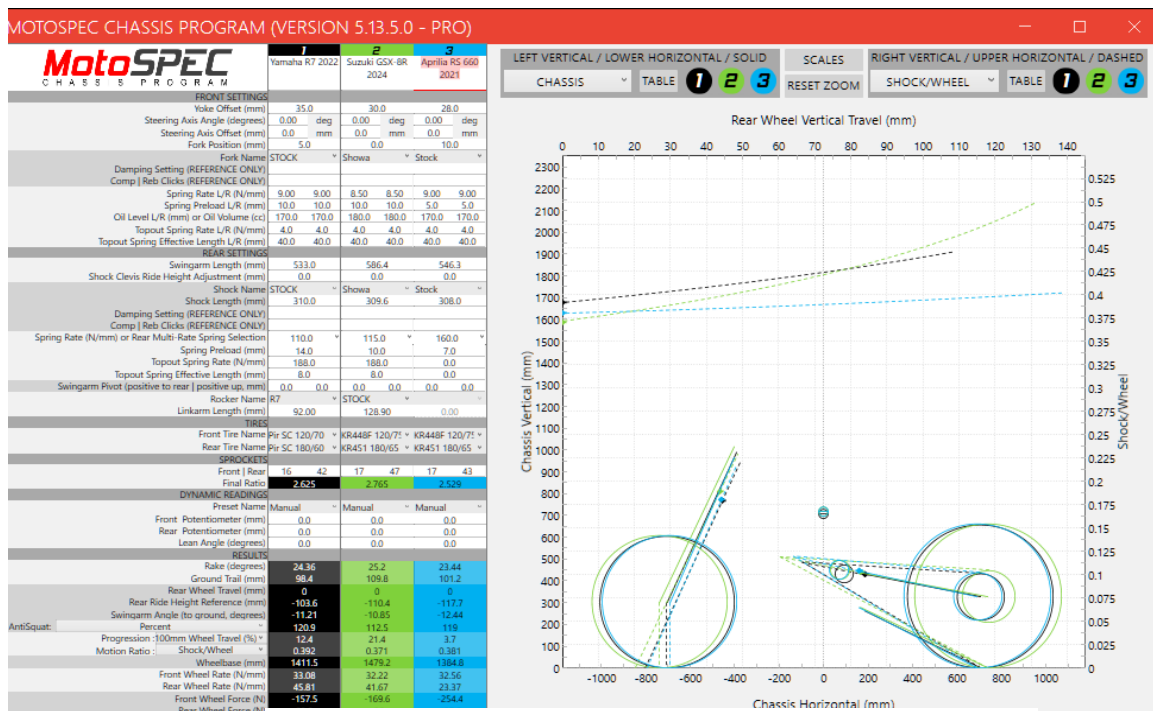


Figure. 11 MOTOSpec Chassis Geometry Schematic Diagram

3.1 Yamaha R7 (2022)

The R7 exhibits a far more modern and moderate wheelbase, steep steering angle, refined trail whilst balancing agility with high-speed stability. Suspension geometry is also reflected far better than the previous older motorcycles, ensuring consistent front-end management/engagement. While the swingarm and shock linkage optimise anti-squat during corner exits. Lean initiation is rapid, whilst mid-cornering geometry remains stable. This allows for far more responsive and predictable handling. Compared with the ZX750-J, the R7 is significantly more agile at mid-range speeds and offers more forgiving high-speed steering responsiveness, reflecting an engineering design prioritising track and street performance.

The R7 helms from the Yamaha R6 but is tailored towards a well-rounded and agile riding experience with a complimentary riding experience that balances handling and power (Neeves, 2022). The wheelbase holds a shorter length than the GSX-8R allowing for more forgiving mid-corner adjustments. The weight distribution of the Yamaha R7 is designed to strike a balance between agility and stability. Yamaha achieves this by positioning the battery and engine low, as well as keeping the overall weight distribution evenly balanced between the front and rear tyre. This makes the R7 feel significantly more planted and predictable in corners, providing a neutral handling characteristic without excessive front-end or rear-end bias.

One of the key factors influencing the Yamaha R7's handling is its dynamic load transfer. The way the motorcycle's weight is under acceleration, braking and cornering. This aspect of motorcycle geometry is integral to the performance of track riders, whom of which require precise control during shifts in weight. The stability of the motorcycle is paramount to performance whilst navigating through corners at aggressive speeds.

3. Interpretation of Geometry, Handling, Gear ratios and speed characteristics: Yamaha R7 (2022) & Suzuki GSX-8R (2024)

During acceleration, the R7 experiences a rearward weight transfer that places more load on the rear tyre, improving traction during aggressive acceleration. However, this is not as pronounced as on motorcycles such as the ZX750-J, which has a more rearward weight bias to enhance grip. The R7 maintains a neutral weight distribution, so its handling remains predictable during hard acceleration and braking, subsequently giving the rider more control over the motorcycle's behaviour.

During braking, the forward load transfer causes the front suspension to compress, allowing for greater front-end grip. The rider's position on the bike also plays a role in how weight is distributed and the rider's ability to manage the load transfer is crucial to maintaining the R7's stability during aggressive riding.

The Yamaha R7 is powered by a parallel-twin engine of 689cc (Cubic centimetres), which has a nice balance of mid-range torque and performance. The engine is paired with a typical 6-speed gearbox, designed for precision shifting and speedy acceleration. Built for responsiveness and rather than top-end speed, with the gearing being specifically designed to utilise the optimal powerband for the R7's engine.

3.2 Suzuki GSX-8R (2024)

Suzuki has historically been known for balancing performance with stability in their sportbike models. This approach is particularly evident in the GSX-8R, a middleweight sportbike primarily aimed at offering both stability on the road, speed and excellent handling characteristics inspiring massive confidence on twisty roads and track days.

The engineering design of the GSX-8R stems from Suzuki's previous models such as the GSX-R series and SV650. The SV650 is known for its front-end stability and ease of use pertaining to the rider. The GSX-8R continues this design practicality.

In terms of chassis design, Suzuki tends to favour a relatively relaxed rake and increased trail compared to other manufacturers like Yamaha and Kawasaki, which have a reputation for designing motorcycles that boast quick handling and agility. A relaxed rake and increased trail, while not as responsive in terms of initial steering input, provides stability at higher speeds and under braking. Making the motorcycle more predictable in terms of performance reliability. This benefits riders who prefer consistency throughout their track day experience.

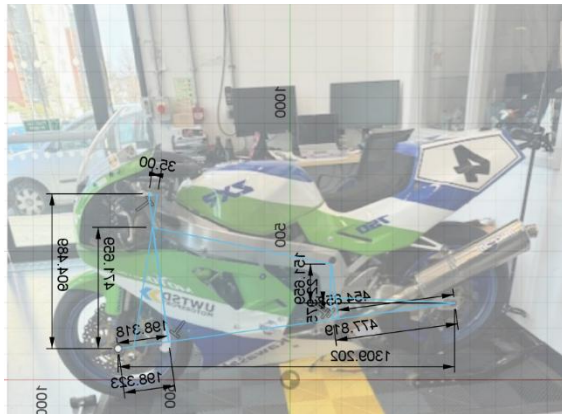
The GSX-8R incorporate a larger wheelbase compared to that of the Yamaha R7. This longer wheelbase provides far more stability, especially at higher speeds or transitioning through rapid direction changes. The result is a motorcycle that streamlines a stable response during aggressive cornering. Although, not as quick to respond to steering input as the Yamaha R7. Compared to that of the RS250, which is a more extreme race-orientated machine, the GSX-8R prioritises stability, comfort and predictability ([Stevens, 2024](#)). Its slower steering response might not appeal to riders looking for extreme agility and quick handling like the RS250.

4. Conclusion

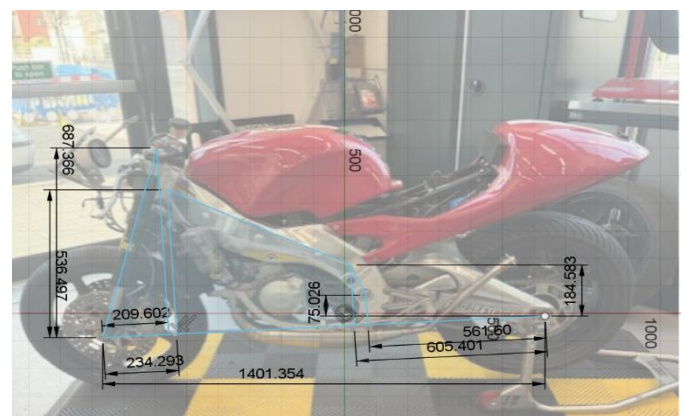
The Kawasaki ZX750-J and Aprilla RS250 represent two very different engineering philosophies in sportbike design. Another consideration to take into effect, stated by (Shippey, 2010), is that the design history of the ZX750-J is inherent to its success on the market. The ZX750-J's focus on high-speed stability, rearward traction and power-driven performance contrasts with the RS250's emphasis on agile cornering, low CoG and predictable chassis behaviour. The ZX750-J excels in straight-line performance which is typical of an inline-4 engine, while the RS250 thrives in tight corners and track environments which is more a testament to its on-track capabilities.

Meanwhile, the Yamaha R7 and Suzuki GSX-8R embody modern design approaches that balance agility and comfort. The R7 focuses on track-oriented responsiveness, offering rapid handling and precision, while the GSX-8R prioritises composed stability and road comfort, making it ideal for more relaxed, everyday riding.

Each motorcycle's design reflects a set of engineering priorities that shape its performance and handling characteristics. Understanding the ZX750-J's high-speed performance, the RS250's agility, the R7's track precision or the GSX-8R accessibility lends clarity to how geometry weight distribution and dynamic load transfer influence these aspects of a motorcycle's behaviour. It is paramount that data reflects the environment in which it was measured in and that real-world applicability is incredibly unrealistic given road conditions in the UK, Speed limits and adherence to public safety. Unless present at a race circuit, it is very unlikely that these statistics can be replicated naturally or legally.



*Figure, 12 ZX750-J CAD
measurements*



*Figure, 13 Aprila RS250 CAD
measurements*

5. References

riding attitude, according to (Paredes, 2024), would be to add a steering dampener.	Paredes, P. (2024). <i>Understanding Steering Dampers and Their Benefits</i> . [online] Paulsen Motorsports. Available at: https://www.paulsenmotorsports.com/what-is-a-steering-damper-and-do-you-need-one/ [Accessed 14 Dec. 2025].
. Outlined by (Jackson, 2025), the death wobble, although rare, is more common in motorcycles with	Jackson, R. (2025). <i>How to Prevent Death Wobble Motorcycle: My Honest Guide 2025</i> . [online] Biker Guides. Available at: https://bikerguides.com/how-to-prevent-death-wobble-motorcycle/ [Accessed 14 Dec. 2025].
complimentary riding experience that balances handling and power (Neeves, 2022)	Neeves, M. ed., (2022). <i>Is the Yamaha R7 the king of everyday sports bikes? MCN REVIEW</i> . [online] Motorcyclenews.com. Available at: https://www.motorcyclenews.com/bike-reviews/yamaha/r7/2022/ [Accessed 14 Dec. 2025].
the GSX-8R prioritises stability, comfort and predictability (Stevens, 2024).	Stevens, C. ed., (2024). <i>2024 Suzuki GSX-8R: Proper sportsbike, or comfy all-rounder? MCN Review MCN review</i> . [online] Motorcyclenews.com. Available at: https://www.motorcyclenews.com/bike-reviews/suzuki/gsx-8r/2024/ [Accessed 14 Dec. 2025].
Motospec Yamaha R7 and Suzuki GSX-8R (FIGURE 11)	MotoSPEC CHASSIS PROGRAM - HOME

5. References

different engineering philosophies in sportbike design. Another consideration to take into effect, stated by (Shippey, 2010),	Shippey, M. ed., (2010). <i>Bike Icon: Kawasaki ZXR750</i> . [online] Visordown. Available at: https://www.visordown.com/features/general/bike-icon-kawasaki-zxr750 [Accessed 14 Dec. 2025].
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