Analysis of Steel Structures with the Use of Fluid Viscous Damper for Different Plan Aspect Ratios As Per Is 1893:2016

Khizeruddin[1] Dr. J N Vyas[2]
[1]PG Student [2]Professor
[1,2]Department of Civil Engineering
[1,2]Mahakal Institute of Technology and Management, Ujjain, India

Abstract— Earthquake produces huge impact in terms of life, money and failure of structure .From the study of past earthquakes, it has been concluded that conventional structure disintegrate or got damaged during ground shaking. Hence it is very essential to design the structure to prevent from such earthquakes. Now a day, the seismic protection using passive controlling devices become more admired by using seismic dampers. From previous research it has been observed that one of the most admired dampers which can be easily used is fluid viscous damper due to its efficiency in controlling inter story drifts, floor acceleration and other structural parameter. It also acts like a shock absorber which dissipates more energy during strong ground motion. Various researches have been carried out for enhancing the effectiveness of seismic control system and there methodology. The aim of this study is to observe the behaviour of such passive controlling devices for seismic control for different aspect ratio of building at different positions. For which the Linear Dynamic analysis for G+5 Storey Steel Structure with high seismic intensity was carried out in the present work using Etabs. In the result, the impact of such devices in storey displacement, drift and base shear were determined and compared. From which we can conclude that Steel Building with setting up of FVD at its corner shows high effectiveness on seismic parameters.

Keywords: Fluid Viscous Damper (FVD), Aspect Ratio, Seismic analysis, Base Shear, Drift, Displacement, IS 1893 – 2016

I. INTRODUCTION

There is a huge demand in multi-story building due to population rise in recent years; the safe factor of the structure is to be considered, as the number of stories goes high especially in terms of seismic activities [1-4]. Since the seismic forces are un-predictable and causes heavy damage during its occurrences, it is necessary to know the structural behaviour and reactions during an Earthquake. Earthquake creates great devastation in terms of life, money and failure of structure .examples from past earthquakes proves that conventional structure collapse or got damages during ground shaking. So, retrofitting of structure is necessary to protect human life ensuring that the structure will not collapse. The seismic protection using passive controlling devices now become more popular such as seismic dampers.

Nowadays rapid growth in population an industries space demand getting increasing which leads to high rise building in cities. Also we have to construct the buildings in seismic zones .hence its necessary to design our building structure seismic forces using some suitable techniques like seismic energy dissipating devices, base isolation. Seismic control techniques are accepted all over globe. It can be used as retrofitting purposes to provide flexibility to the structure. Dampers are available in wide varieties in the markets. One of the most popular dampers is fluid viscous damper because of enhancing performance and significant energy reduction.

A. Fluid Viscous Damper (FVD)

In recent years fluid viscous damper is fused in more Earthquake resistant buildings. Fig 1 shows the schematic representation of viscous damper. When the damper is applied externally in the piston rod, it produces a damping effect through 'to and fro' medium. The friction force occurs in the piston, shaft and cylinder damping force is compost.
The conventional damping force of VFD is imposed by,

$$F = CV^{\alpha}$$

Where F is the damping force, C is the damping coefficient; v is the velocity of the piston and α is the damping.

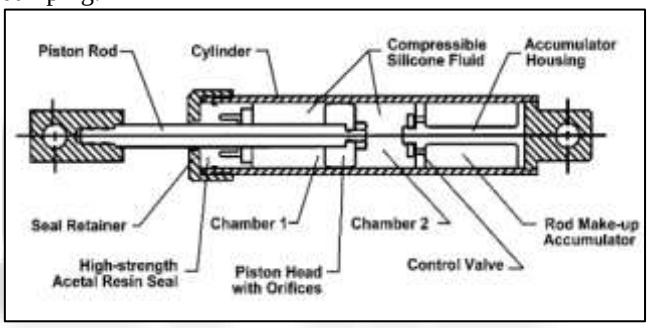


Fig. 1: Fluid Viscous Damper (FVD)

The reason for getting the popularity of FVD is its capability increasing damping of structure .it provides additional damping to structure without increasing forces in members. Thus For Fluid viscous dampers identifies the characteristics of control devices. In this study to determine damping coefficient

$$C = 2m\xi\omega$$

To find the damping coefficient, above equation is being used. Where, m is the total mass in the floor, ω is the natural frequency and ξ is the damping coefficient.

II. OBJECTIVES OF THE STUDY

To design such kind of structures which will sustain in severe earthquakes in various earthquake prone zones and which will lead to reduce the harm of catastrophic as well as economic losses. Various studied carried out using damper in SMRF frames, toggle bracing system. Some research work focus on laboratory test using dampers. Various studies carried out using computer based programming software. The main aim of the researcher to focused on optimum placement of damper to reduce seismic performance and focused on cost as well. On the basis of the previous researches, the following objectives of this paper related to FVD are –

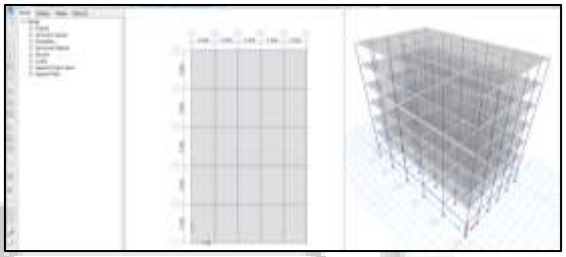
1) To understand the behaviour of FVD in Steel Structural System under linear dynamic analysis.

2) To find out the displacement and Drift of the structural system using FVD under linear dynamic analysis.
3) To carry out the study by changing the position of FVD and find out the optimum position.
4) To find the effect of aspect ratio on structural system using FVD.
5) To evaluate the overturning moment and base shear of structural system with and without FVD.

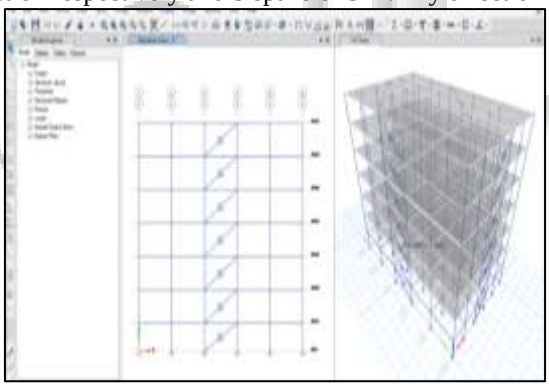
III. Structural Modelling and Analysis

In this present section, the 3 D model of steel structure building of G+5 storied building have been modelled. The linear dynamic analysis as response spectrum analysis been performed for steel building model using IS 800:2007 and IS 1893:2016 with the help of ETABS Software. The following models are analyzed in this work.

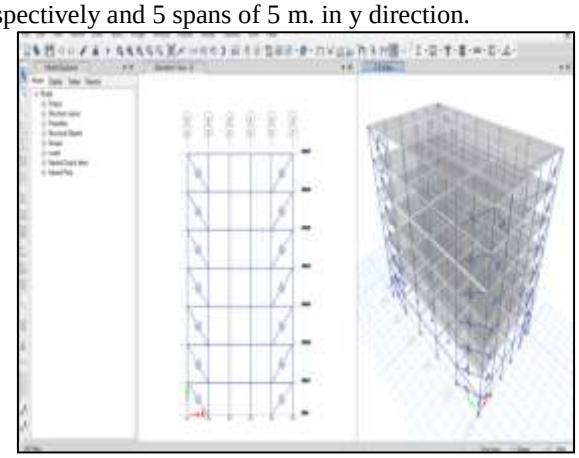
Model 1,7,13 – Regular Frame with 5 spans of 3m., 4 m. & 5 m. in x direction respectively and 5 spans of 5 m. in y direction



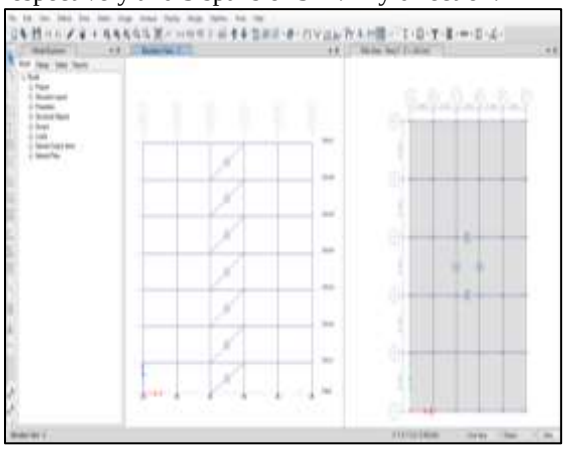
Model 2,8,14 – Regular Frame with FVD at the centre of the periphery with 5 spans of 3m., 4 m. & 5 m. in x direction respectively and 5 spans of 5 m. in y direction



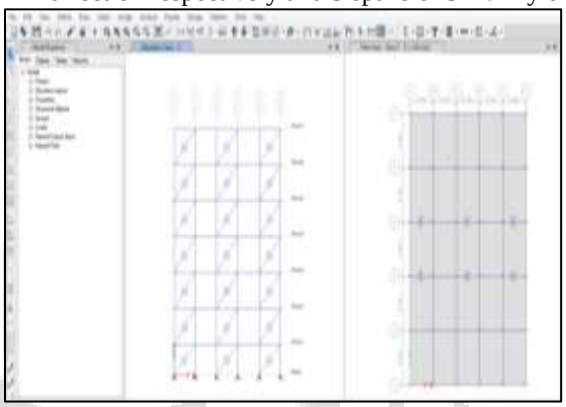
Model 3, 9, 15 – Regular Frame with FVD at its corner with 5 spans of 3m., 4 m. & 5 m. in x direction respectively and 5 spans of 5 m. in y direction.



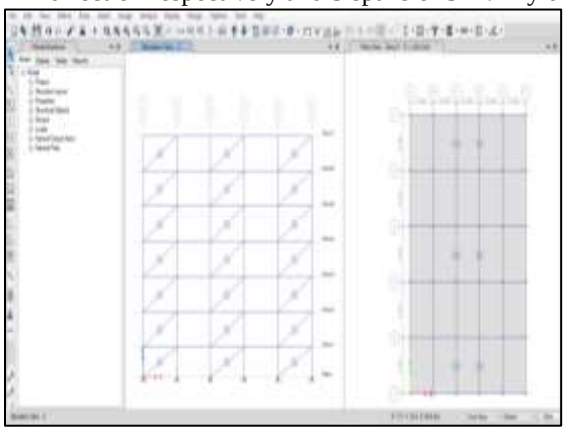
Model 4, 10, 16 – Regular Frame with FVD at its core with 5 spans of 3m., 4 m. & 5 m. in x direction respectively and 5 spans of 5 m. in y direction.



Model 5, 11, 17 – Regular Frame with FVD at the extreme point along X axis with 5 spans of 3m., 4 m. & 5 m. in x direction respectively and 5 spans of 5 m. in y direction.



Model 6, 12, 18 – Regular Frame with FVD at the extreme point along X axis with 5 spans of 3m., 4 m. & 5 m. in x direction respectively and 5 spans of 5 m. in y direction.



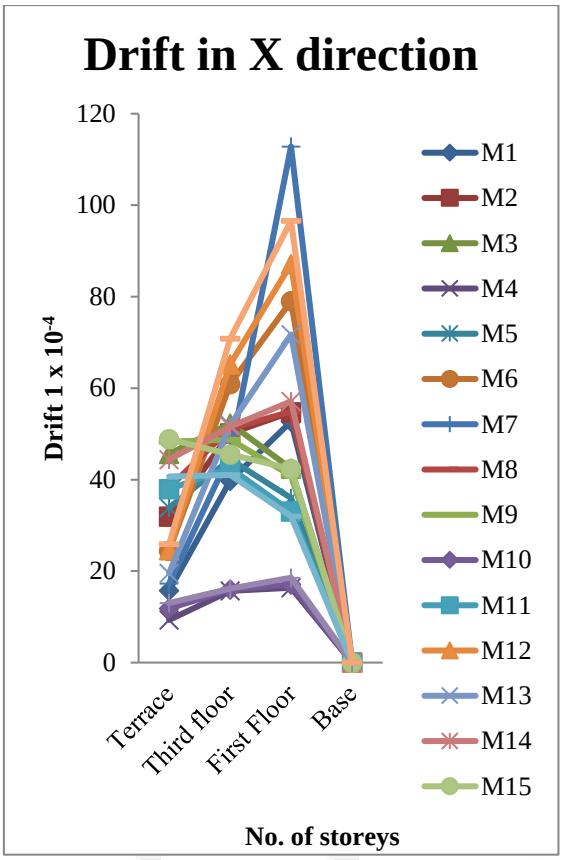
A. Input Data for FVD –

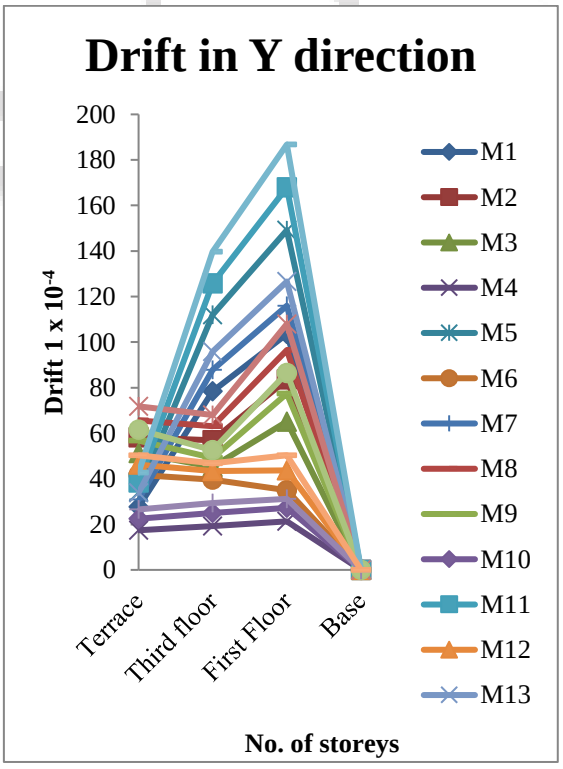
Input Parameters for Structural System:
Input Parameters :
Steel Structure – G+5 Building
Floor Height – 3.6 m.
Grade of Concrete – M 25
Grade of Steel – FE250 (STEEL SECTIONS)
Slab thickness – 150 mm
Size of Columns – ISHB 350
Size of Beams – ISLB 450
Brick Wall Thickness – 230 mm
Live Load – 3 KN/m^2
Seismic Zone – V (Z = 0.36)
Importance Factor I - 1
Soil Type – II Medium
Building Type R – (5) SMRF DETAILING AS PER SP 6 (AS PER IS 1893:2016)
Type of Building – Regular

IV. RESULTS

A. Drift

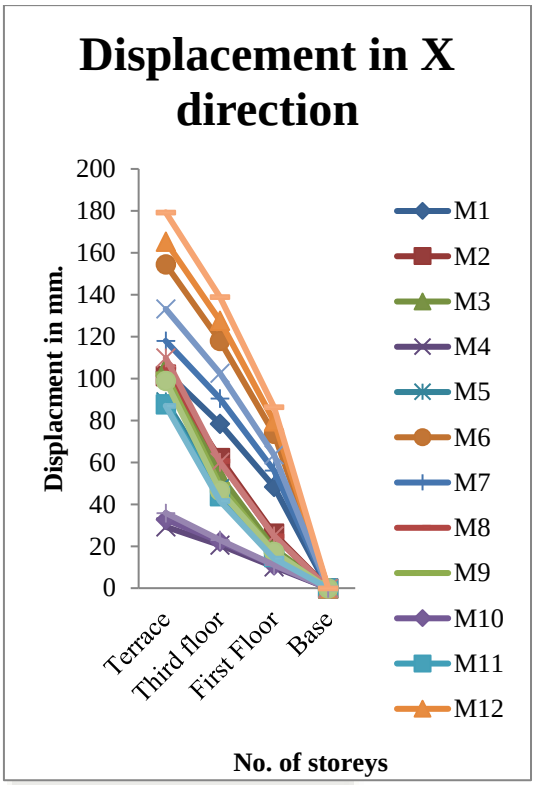
Below figures compares the drift of all the four models along both X and Y directions. The drift values exceed the permitted drift range which is suggested by IS 1893:2016 Cl 7.11.1[3]. The code recommends a maximum permitted drift value of 0.004H where H is the storey height (H=3.6m) and the permissible drift value is 0.0144.

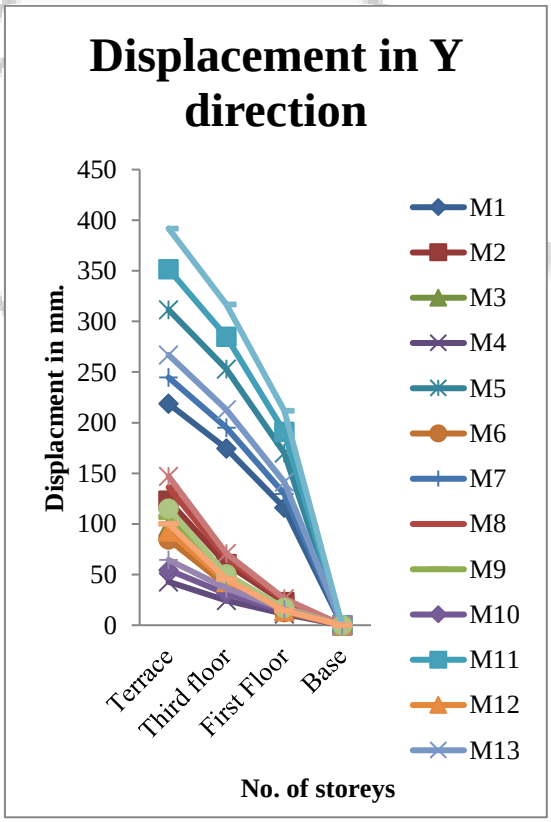




B. Displacement

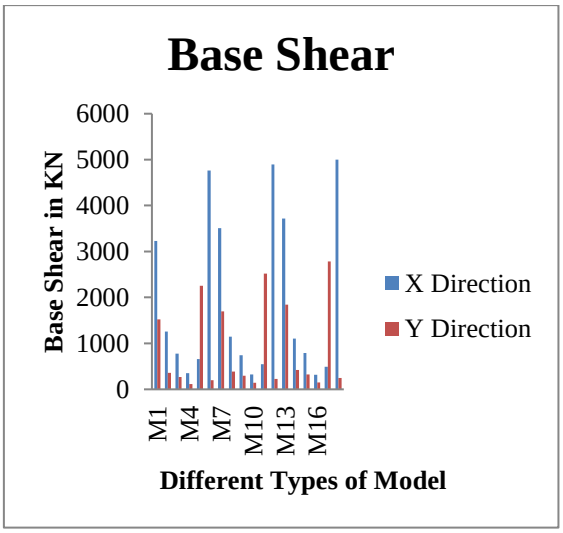
The storey displacements of all the four models are depicted in Figure below. It shows an increase in storey displacement along the height of the structure.



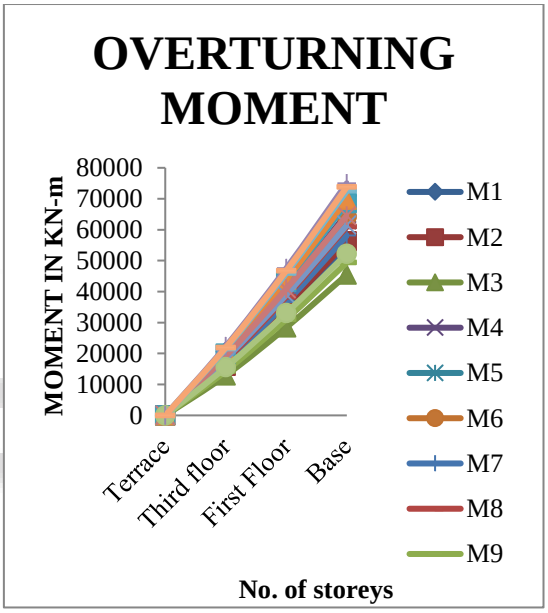


C. Base Shear

The value of base shear mainly depends on the stiffness factor of the structure indicating that structure is much stiffer for seismic response due to its overall mass distribution.



D. Overturning Moment



V. Conclusion

The Seismic Control of Structure using FVD has been summarized below. It indicates the capability of FVD and their importance in modern buildings which can be used to minimize the seismic response of the structures, by controlling inter-storey drifts, displacement and other seismic parameter.

1) The natural time period for the model having the FVD at its core centre part is very much high due to which the natural frequency is low, which shows that the earthquake with low frequency causes the high damages to such type of structure. On the other hand, the natural time period for the building having FVD at its corner shows less value which implies that the frequency will be high and it is desirable for the structure having higher natural frequencies.
2) The mass participated in first three modes in free vibration-al analysis should be 65% which is only fulfilled when the FVD is setup either at centre of the

structure or at the corner of the structure as shown in Model 2, 8, 14 & 3, 9,15 respectively.

3) As per IS 1893, the first two modes in free vibration-al analysis should be pure translation mode which can only be possible when the FVD has been introduced either at centre of the structure or at the corner of the structure as shown in Model 2, 8, 14 & 3, 9,15 respectively.
4) The displacement using FVD at corners reduces by approx 20% in both directions as compared to FVD at centre of the outer periphery of the structure.
5) The value of inter storey drift using FVD at corners reduces by approx 12% in both direction as compared to FVD at centre of the outer periphery of the structure.
6) The value of overturning moment using FVD at corners reduces by approx 17% in both directions as compared to FVD at centre of the outer periphery of the structure.
7) The value of base shear for FVD at corner is 33% less as compared to the models having FVD at centre of the outer periphery of the structure.
8) With the increase in aspect ratio (ly/lx), the displacement also increases by 14% & 10% in x and y direction respectively.
9) With the increase in aspect ratio (ly/lx), the displacement also increases by 10% & 10% in x and y direction respectively.
10) The natural time period for the first mode also increases with the increase in aspect ratio.

When introducing fluid viscous dampers to the building, its behaviour was different under seismic force which can be observed from the results. FVD has more life Efficiency which is almost near to design life of building structure which totally reduced the maintenance cost for dampers. FVD plays an important role to minimize the seismic control with desirable cost.

REFERENCES

[1] Kookalani, S., & Shen, D. (2020). Effect of Fluid Viscous Damper parameters on the seismic performance. Journal of civil Engineering and Materials Application, 4(3), 141-153.DOI: 10.22034/jcema.2020.232288.1025
[2] Sepehri, A., Taghikhany, T., & Ahmadi Namin, S. M. R. (2019). Seismic design and assessment of structures with viscous dampers at limit state levels: Focus on probability of damage in devices. The Structural Design of Tall and Special Buildings, 28(1), e1569. DOI: 10.1002/tal.1569.
[3] Sinha, A. K., & Singh, S. (2017). Seismic protection of RC frames using friction dampers. International Journal of Civil Engineering and Technology, 8(2), 2017.
[4] Ras, A., & Boumechra, N. (2014). Study of nonlinear fluid viscous dampers behaviour in seismic steel structures design. Arabian Journal for Science and Engineering, 39(12), 8635-8648.
[5] Miyamoto, H. K.,& Gilani, A. S. (2013). Seismic Viscous Dampers: A Cost-Effective Solution With Enhanced Performance for Retrofit and New Construction. In Proceedings of the 13th World Conference on Seismic Isolation, Energy Dissipation and Active Vibration Control of Structures, Sendai, Japan, Sept (pp. 24-27).DOI: 10.13140/2.1.4510.4003
[6] Zhou, Y., Lu, X., Weng, D., & Zhang, R. (2012). A practical design method for reinforced concrete structures with viscous dampers. Engineering structures, 39, 187-198.
[7] Munir, A., & Warnitchai, P. (2013). Optimal reduction of inelastic seismic demands in high-rise reinforced concrete core wall buildings using energy-dissipating devices. The Structural Design of Tall and Special Buildings, 22(7), 543-568.
[8] Chen, X. W., Li, J. X., & Cheang, J. (2010). Seismic performance analysis of Wenchuan hospital structure with viscous dampers. The Structural Design of Tall and Special Buildings, 19(4), 397-419.
[9] Tokuda, Yukihiro, and Kenzo Taga. "A case of Strctural Design in which viscous dampers are used to enhance earthquake resisting performance of a Building."
[10] Kim, J., Choi, H., & Min, K. W. (2003). Performance-based design of added viscous dampers using capacity spectrum method. Journal of Earthquake Engineering, 7(01) 1-24. DOI: 10.1080/13632460309350439.
[11] Lee, D., & Taylor, D. P. (2001). Viscous damper development and future trends. The Structural Design of Tall Buildings, 10(5), 311-320.
[12] Symans, M. D., & Constantinou, M. C. (1998). Passive fluid viscous damping systems for seismic energy dissipation. ISET Journal of Earthquake Technology, 35(4), 185-206.

