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THEORETICAL ANALYSIS OF THE FLOW FIELD OVER A FAMILY OF OGIVE B--ETC(U)
JAN 79 R L RICHARDSON, B Z JENKINS

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TECHNICAL REPORT T-79-15

THEORETICAL ANALYSIS OF THE FLOW FIELD OVER A FAMILY OF OGIVE BODIES – A SUPPLEMENT TO MIRADCOM TECHNICAL REPORT TD-CR-77-5

U.S. ARMY MISSILE RESEARCH AND DEVELOPMENT COMMAND

R.L. Richardson and B. Z. Jenkins
Systems Simulation Directorate
Technology Laboratory

12 January 1979

Redstone Arsenal, Alabama 35809

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20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

Local body surface pressure coefficients and Mach numbers are presented for tangent ogive bodies at Mach numbers from 2 to 4.5 and at 0 and 2 deg angle-of-attack. These data were obtained using the US Army Missile Research and Development Command three-dimensional method of characteristics computer code. This volume is intended to supplement MIRADCOM Technical Report TD-CR-77-5, published August 1977.

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I. INTRODUCTION

The plots presented in this report are for body shapes 14, 15, and 16, and partly replace and complete the data on BS 14, 15, and 16 given in Technical Report TD-CR-77-5, Theoretical Analysis of the Flow Field over a Family of Ogive Bodies, dated 16 August 1977 [1].

II. DISCUSSION

The plots shown in this report give values of surface pressure coefficients (CP) (Figures 1-18) and local Mach numbers (Figures 19-21) as they vary with X/D (axial direction). The free stream Mach numbers considered are M = 2, 2.5, 3, 3.5, 4, and 4.5. There are two angles-of-attack: $\alpha = 0°$ and $\alpha = 2°$. For $\alpha = 2°$ data, five different locations on the periphery of the ogive have their pressure coefficient values given. They are $\theta = 0°$, 45°, 90°, 135°, and 180°. Zero degrees is located in the center of the windward side and the θ values advance in increments of 45° to 180°, which is the center of the leeward side. At the right side of the $\alpha = 2°$ plots, θ values are listed. The bottom line is $\theta = 0$ when the θ values on the right increase from bottom to top, and vice versa for θ values increasing in the opposite direction. When there is a crossover of a CP line, θ is labeled to avoid confusion. For the CP versus ogive length (X/D) plots (Figures 1-18), the $\alpha = 0°$ data are subtracted from the 2° angle-of-attack data. This is done to obtain greater resolution. For the local Mach number versus X/D at $\alpha = 0°$, (Figures 19-21), the free stream Mach numbers are labeled increasing in the same direction as the lines.

The US Army Missile Research and Development Command (MIRADCOM) three-dimensional method of characteristics computer code for bodies of revolution [2] was used to obtain the flow-field solutions. This program was provided initial value data by representing the first 5% of the forebody as a right-circular cone and using the Jones cone at angle-of-attack (CONEAL) program [3]. The $\alpha = 2°$ data for local Mach number versus X/D is not given because an incompatibility between program CONEAL and the three-dimensional program was discovered. The incompatibility was that the CONEAL program refined its calculation to resolve the thin vortical layer with its large velocity gradients and accompanying entropy changes, while the three-dimensional program did not do this. In actual flows the boundary layer destroys this vortical layer anyway.

There is also one graph (Figure 22) showing the forebody (ogive) drag coefficient (C_D) versus free stream Mach number (M_∞) for body shapes 14, 15, and 16. The values for Mach numbers below 2.0 were obtained from the MIRADCOM program for transonic flow fields about bodies of revolution including thrust effects and small angles-of-attack. This program is described in MICOM TR-76-23 by Wu, Moulden, and Uchiyama [4].

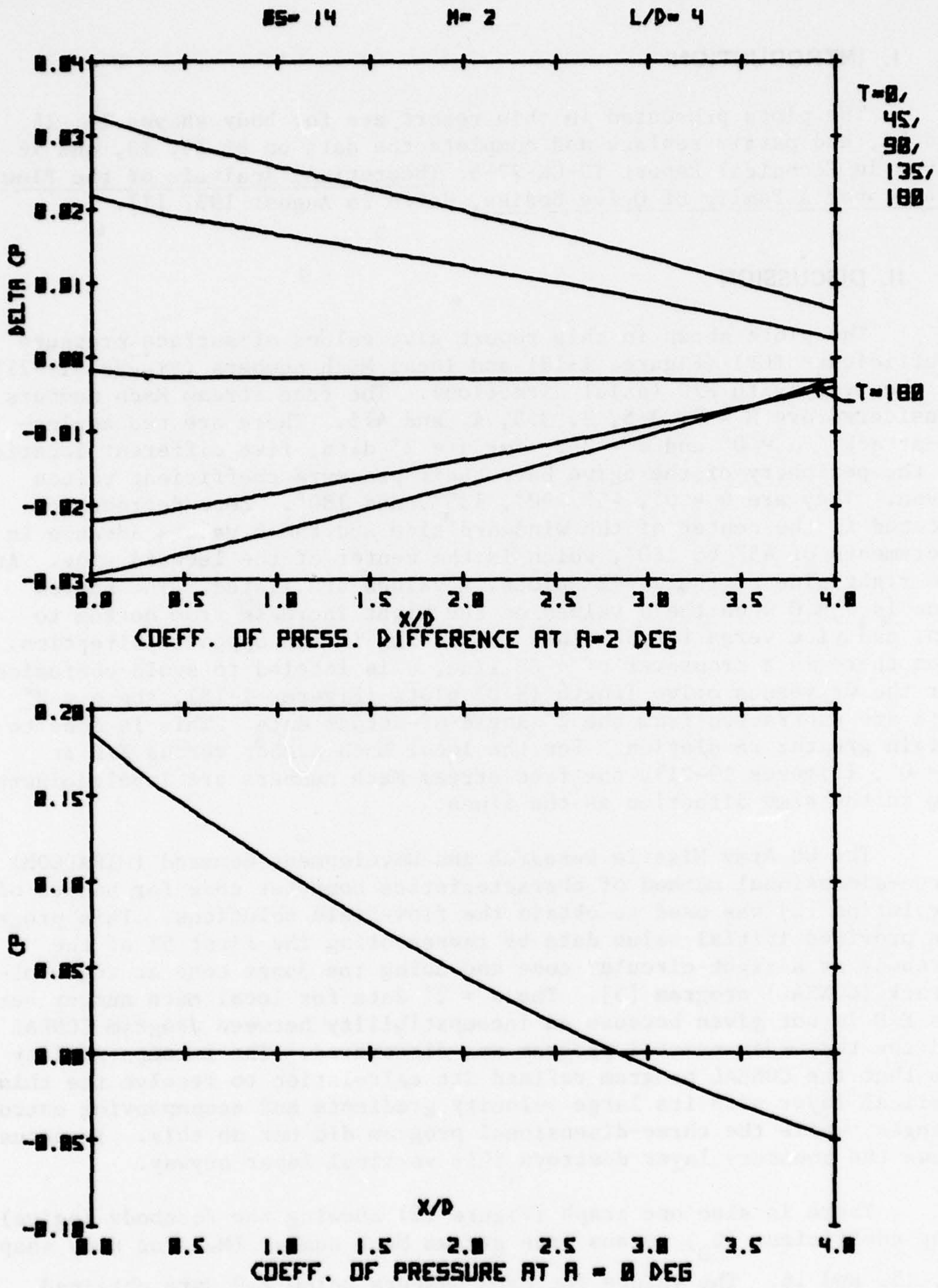


Figure 1. Surface pressure data versus axial direction (BS = 14, M = 2, L/D = 4).

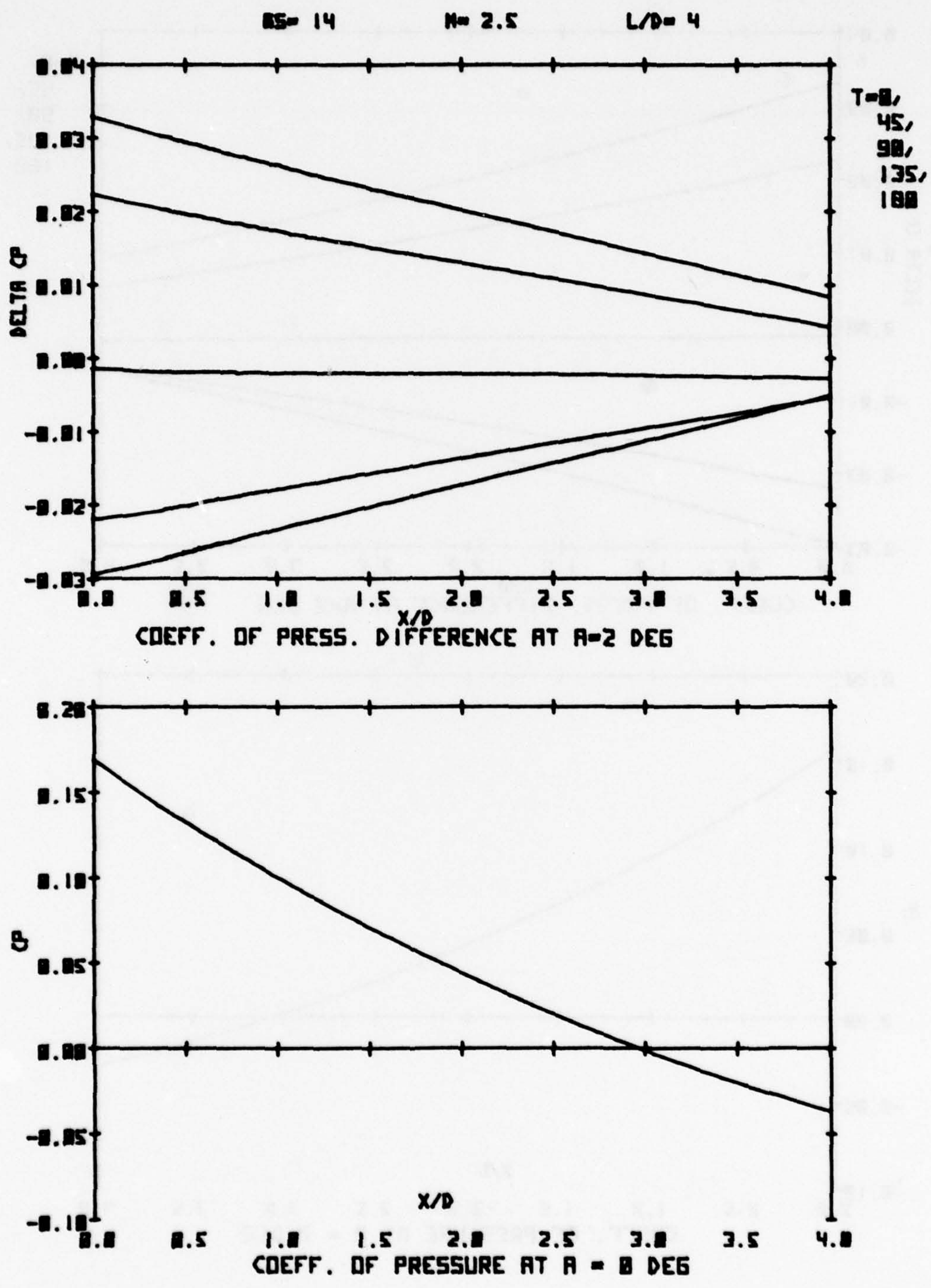
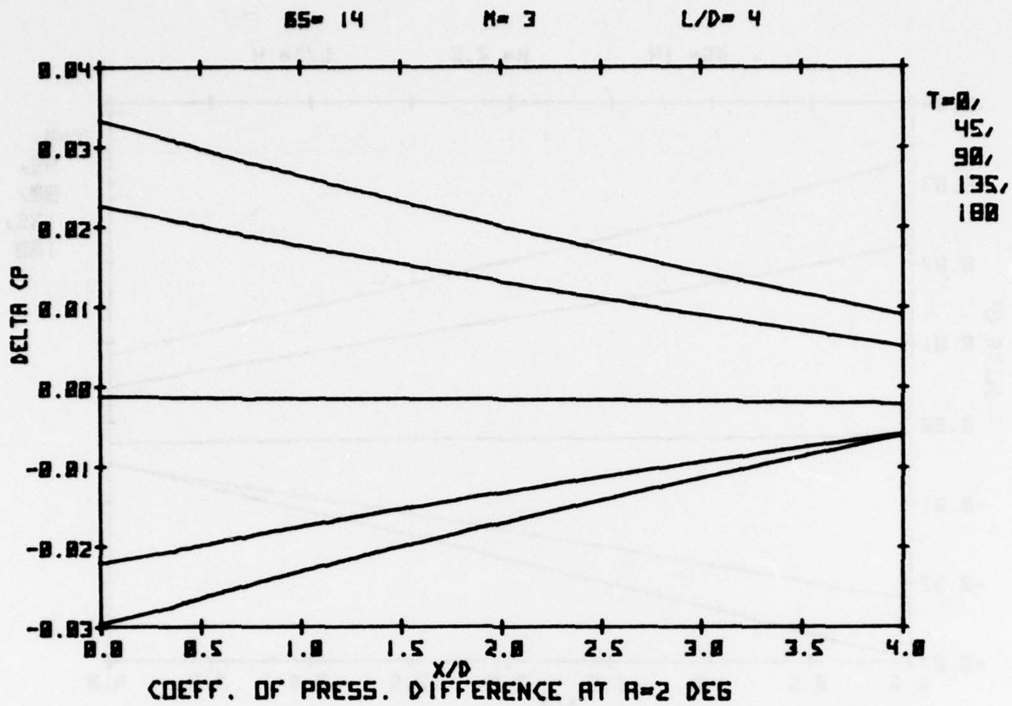


Figure 2. Surface pressure data versus axial direction (BS = 14, M = 2.5, L/D = 4).



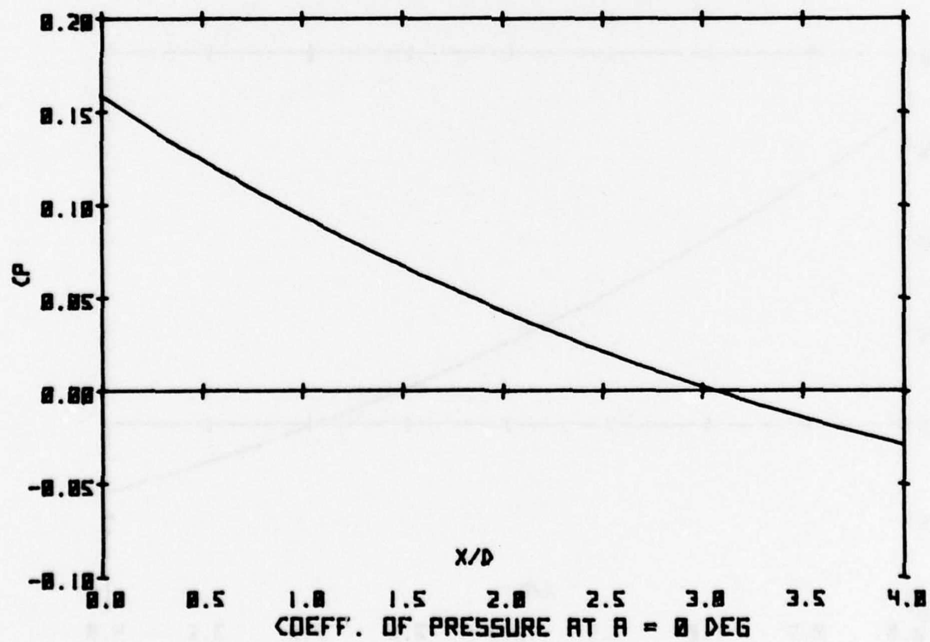


Figure 3. Surface pressure data versus axial direction (BS = 14, M = 3, L/D = 4).

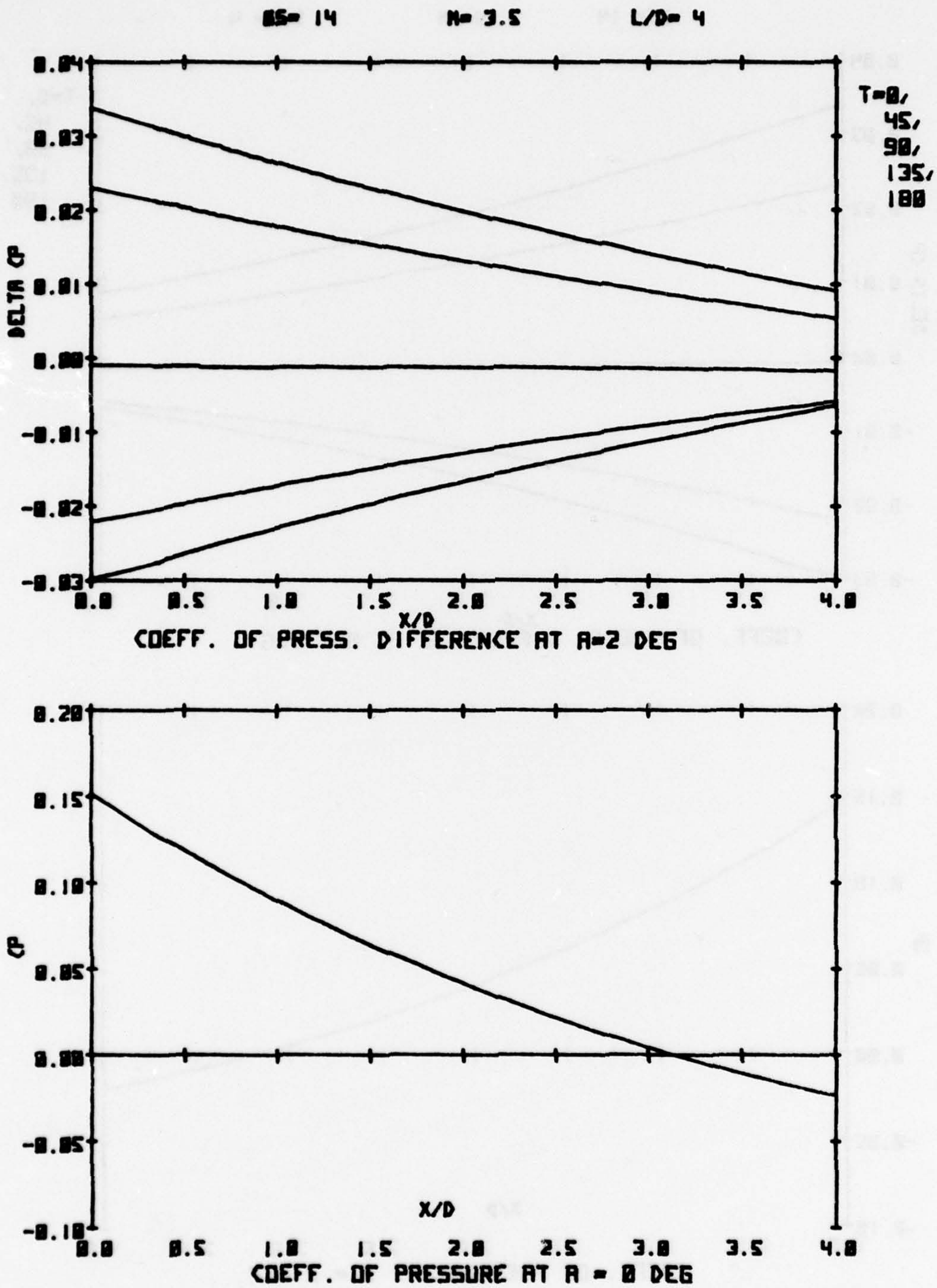


Figure 4. Surface pressure data versus axial direction (BS = 14, M = 3.5, L/D = 4).

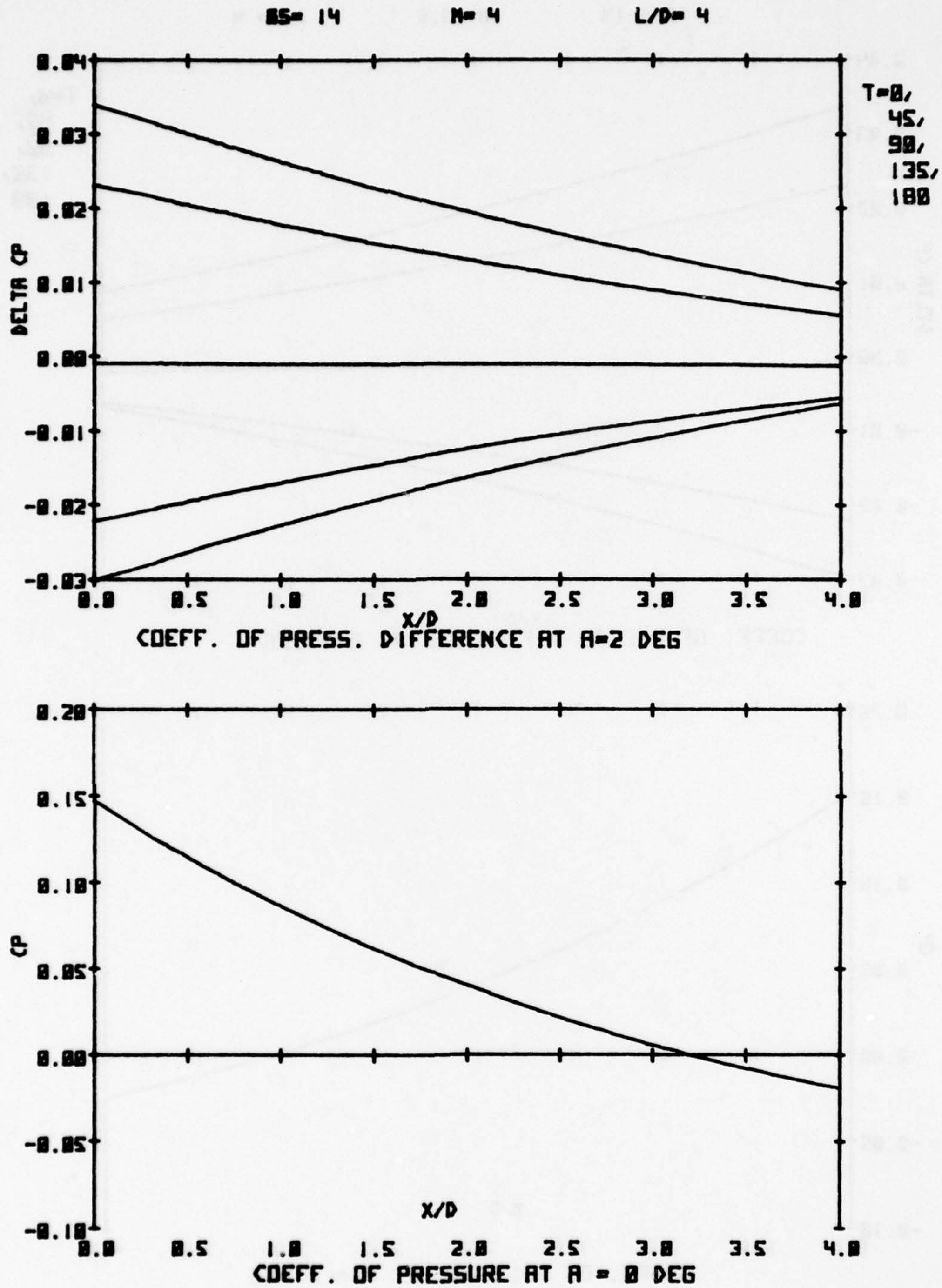


Figure 5. Surface pressure data versus axial direction (BS = 14, M = 4, L/D = 4).

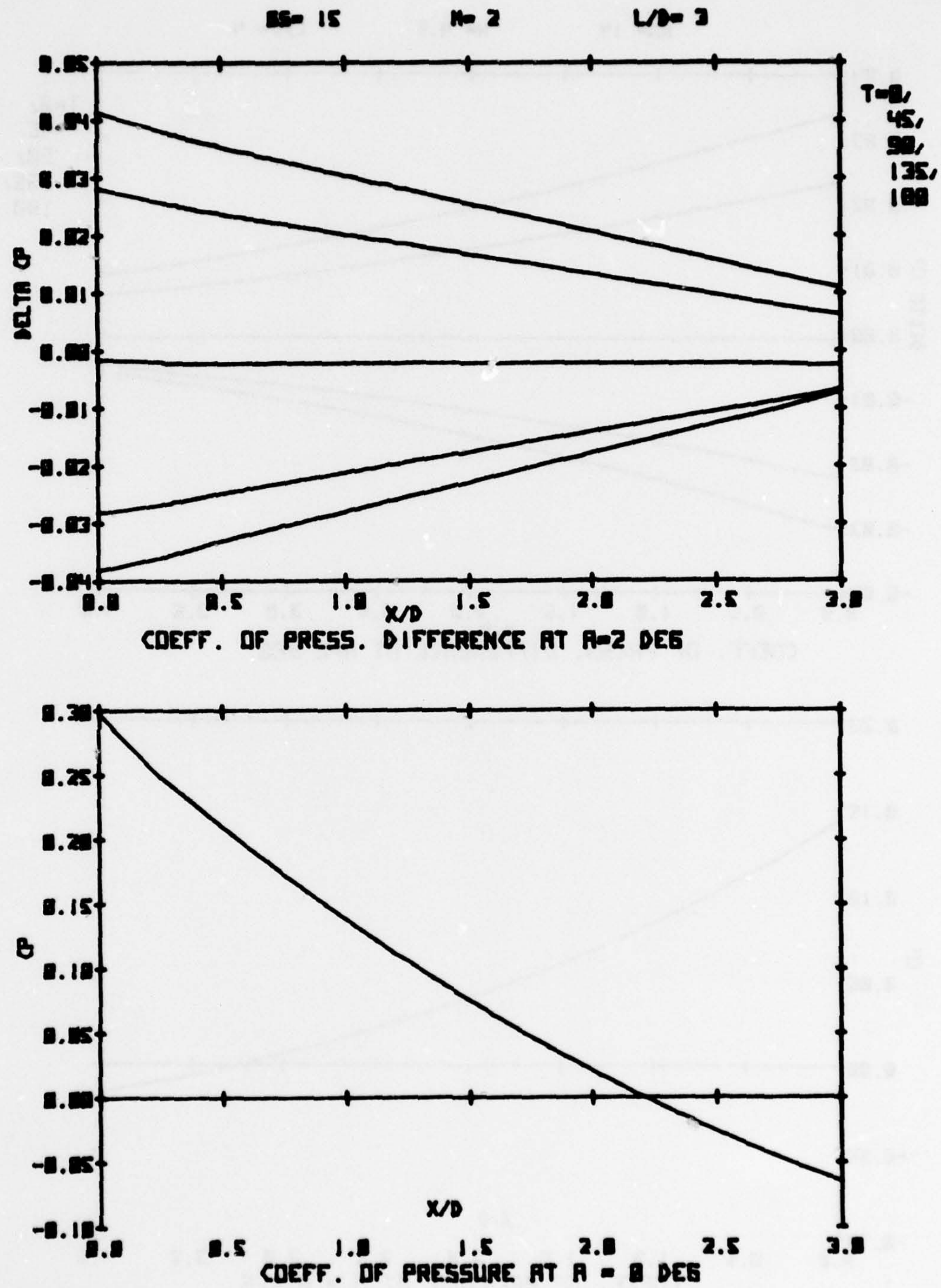


Figure 6. Surface pressure data versus axial direction (BS = 14, M = 4.5, L/D = 4).

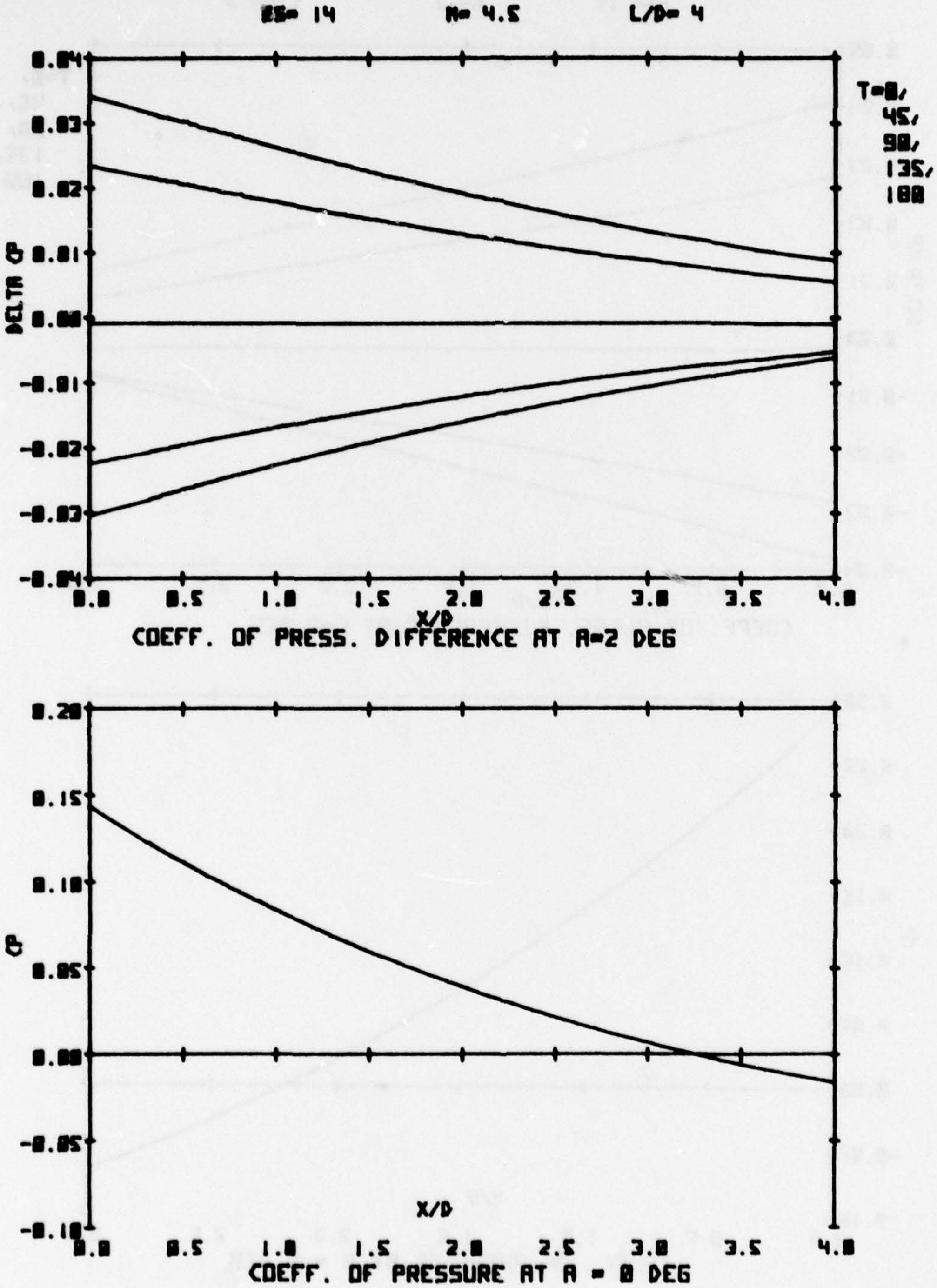
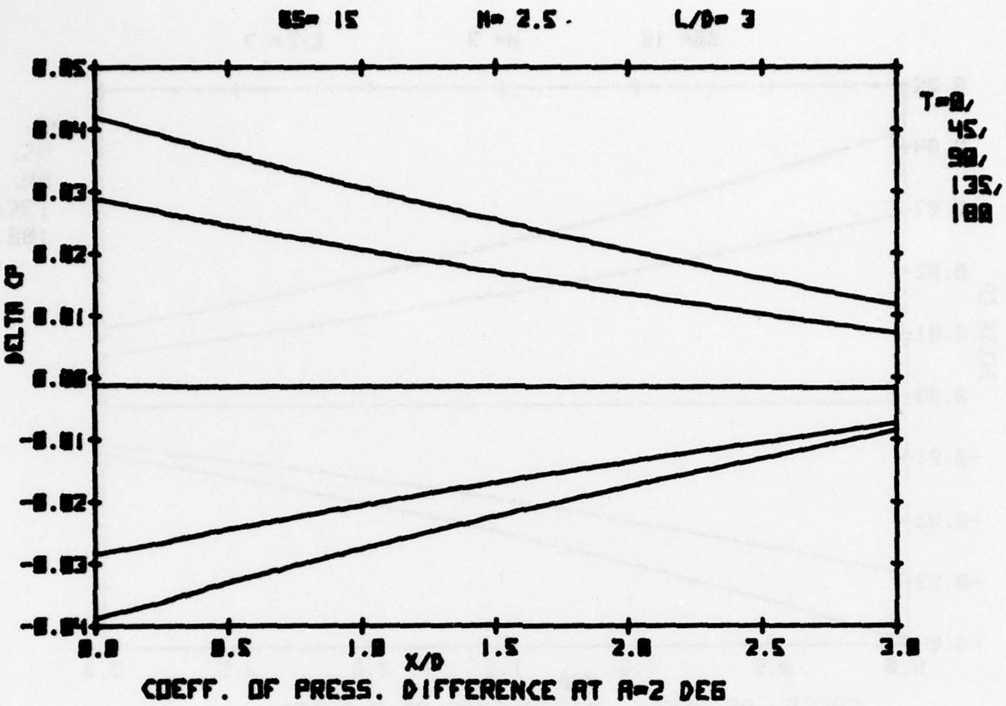
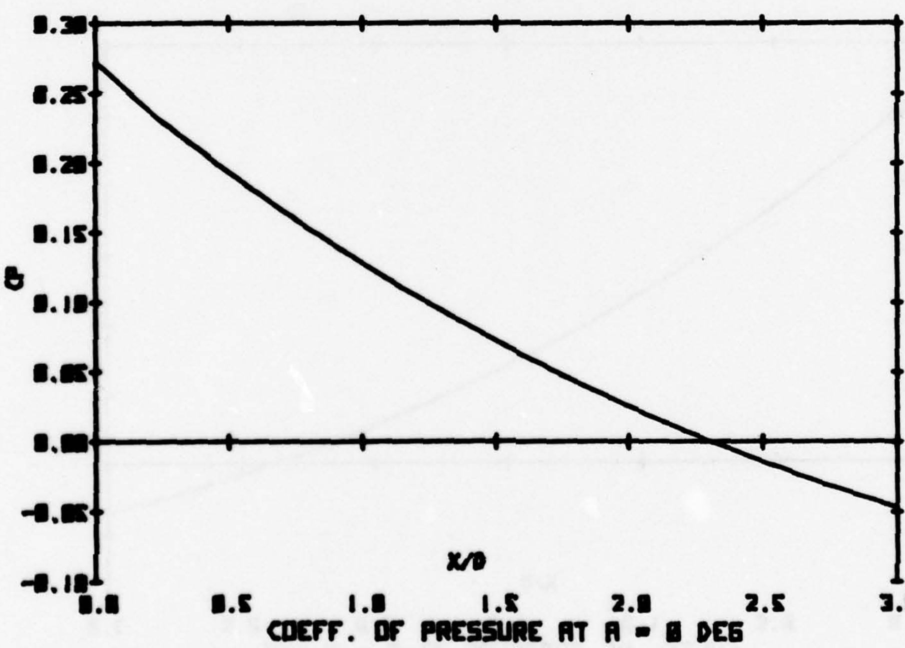


Figure 7. Surface pressure data versus axial direction (BS = 15, M = 2, L/D = 3).





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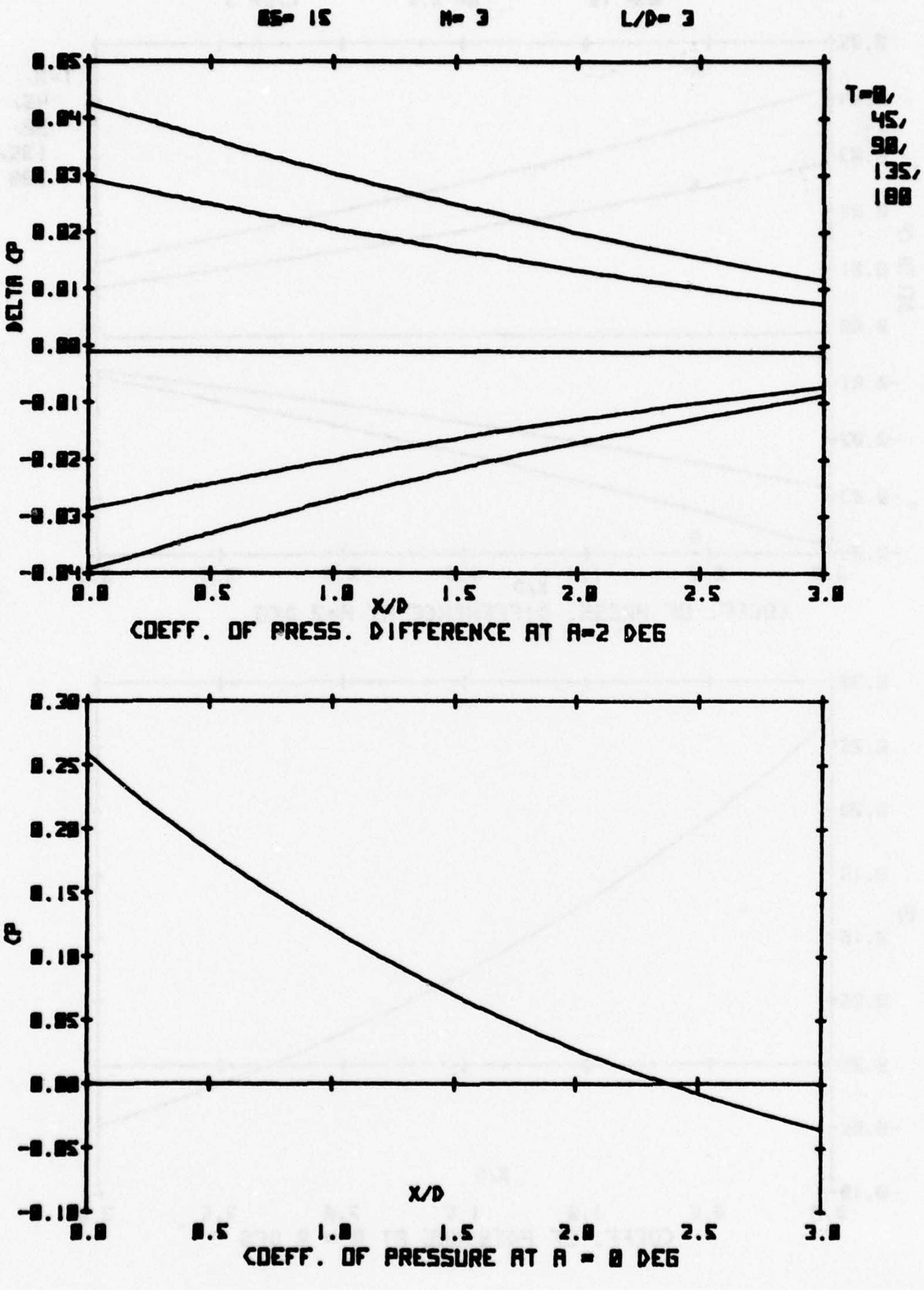

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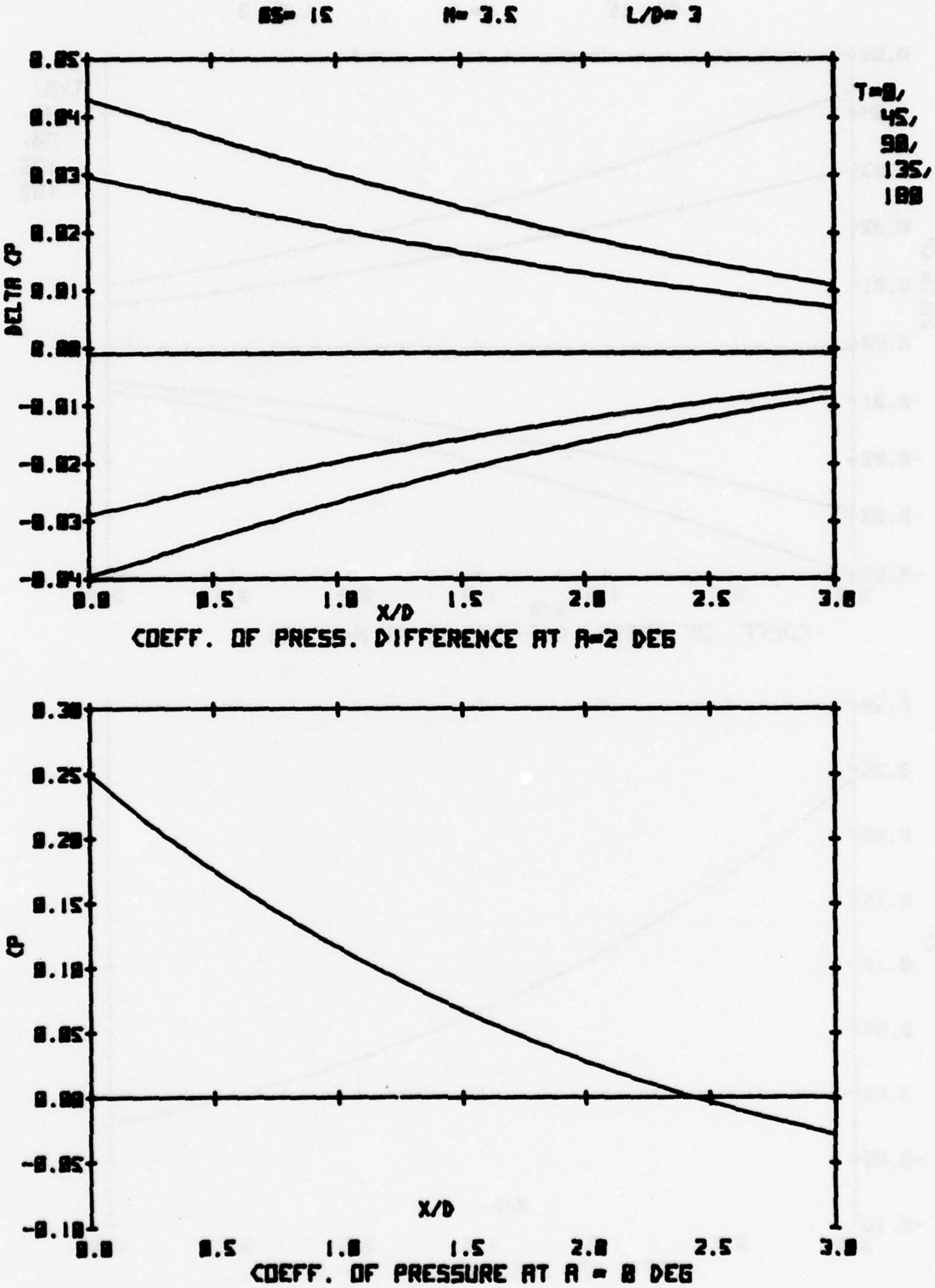
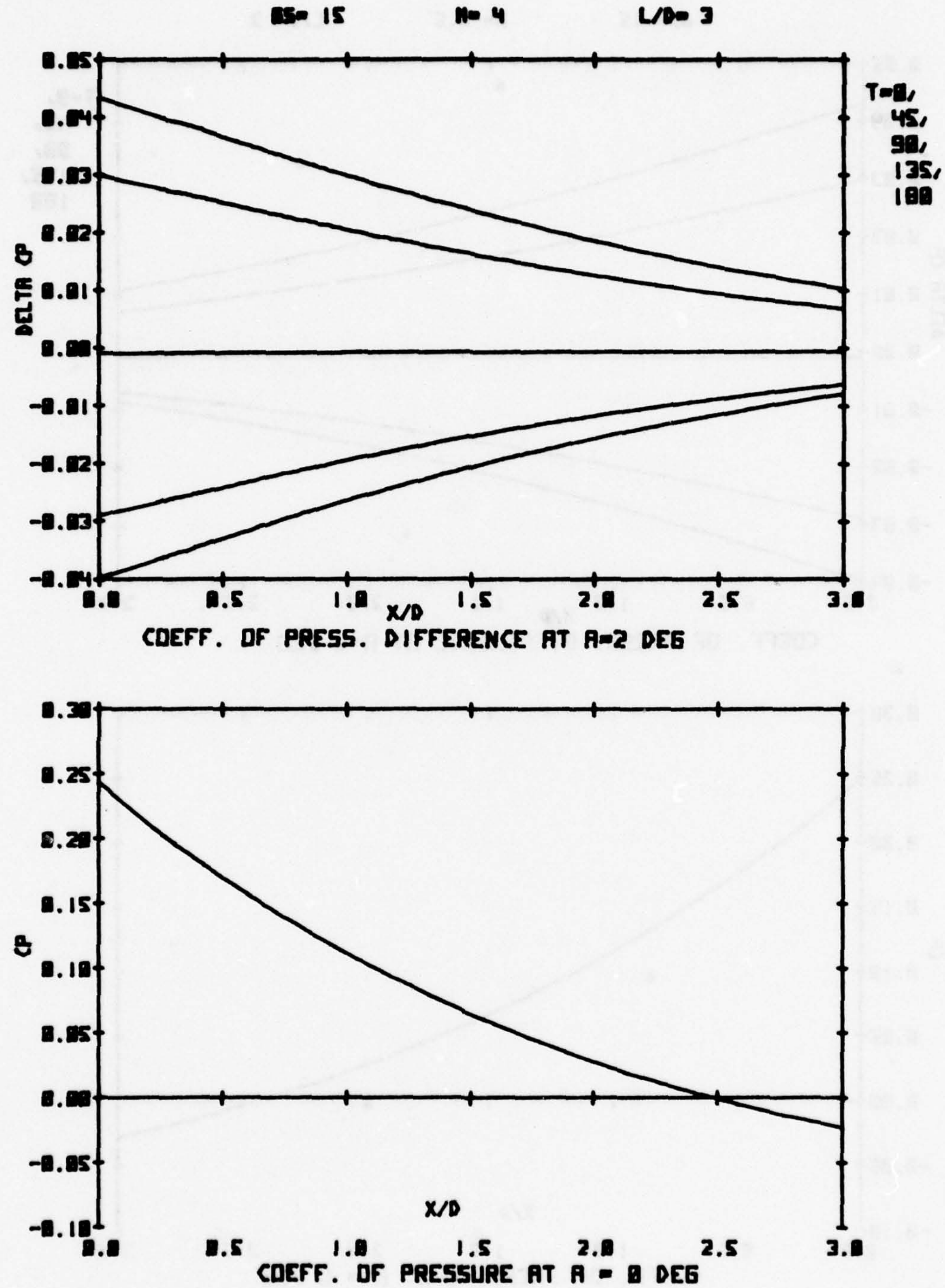


Figure 10. Surface pressure data versus axial direction (BS = 15, M = 3.5, L/D = 3).



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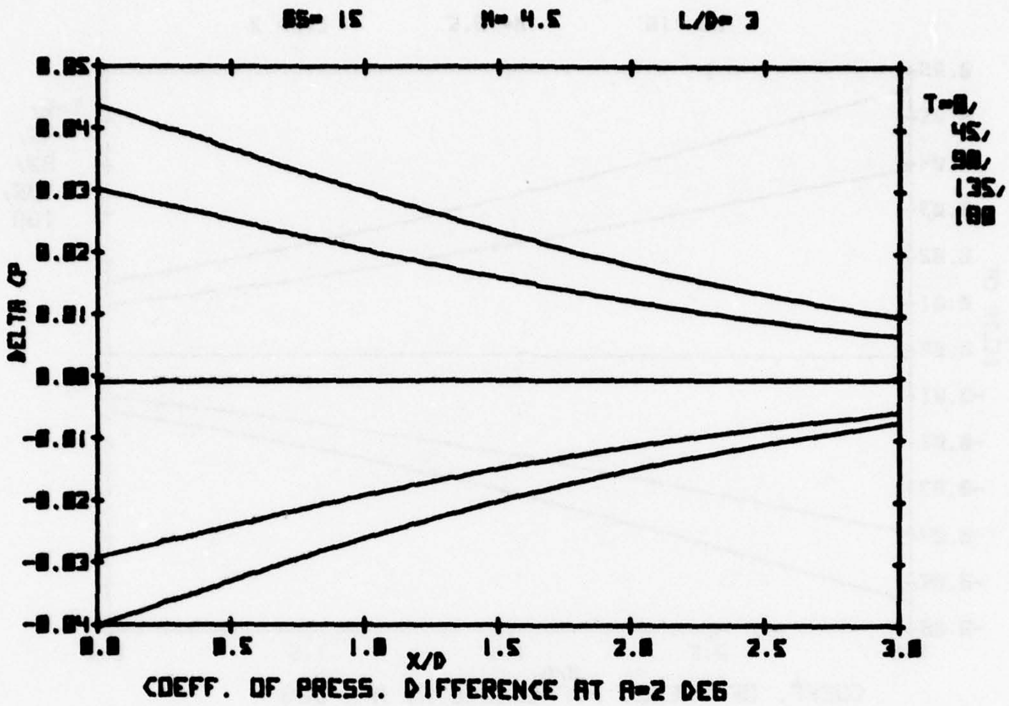

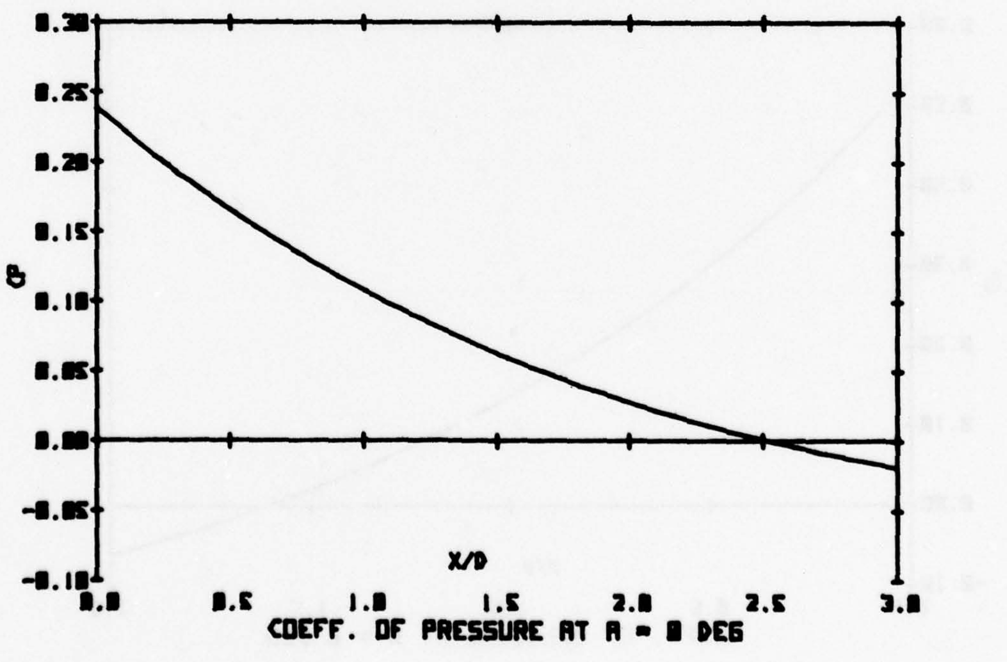

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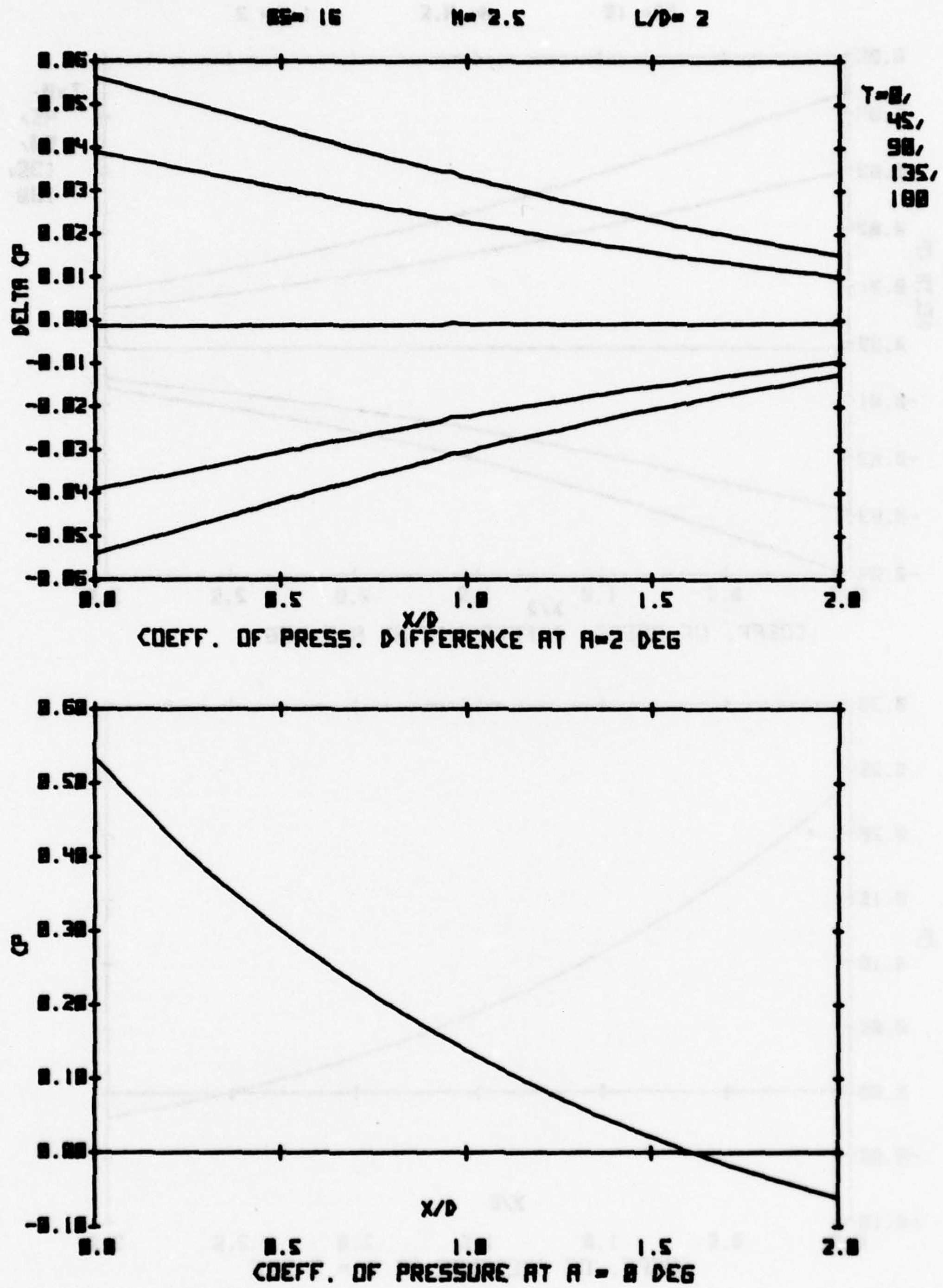


Figure 13. Surface pressure data versus axial direction (BS = 16, M = 2.0 L/D = 2.0).

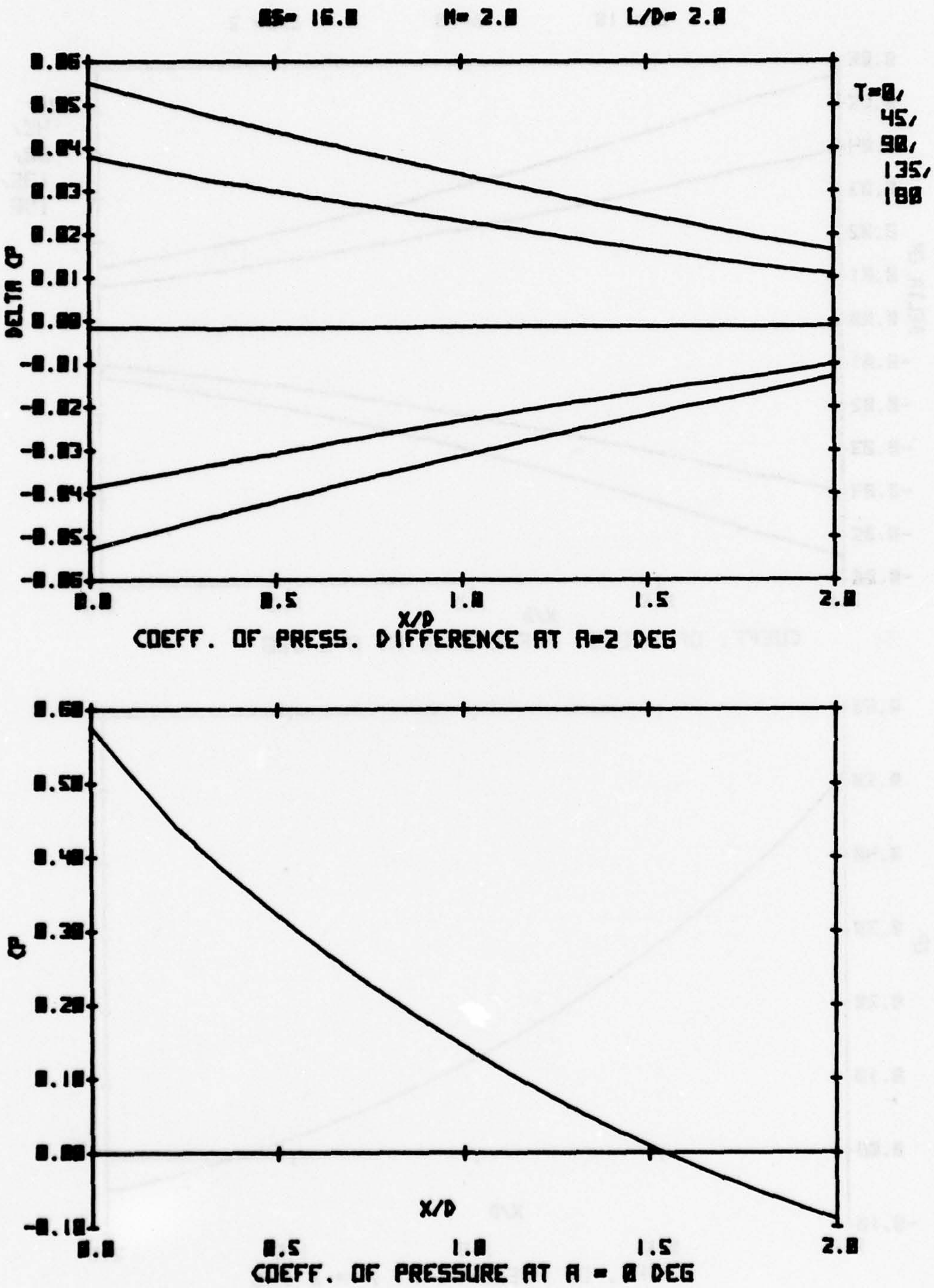
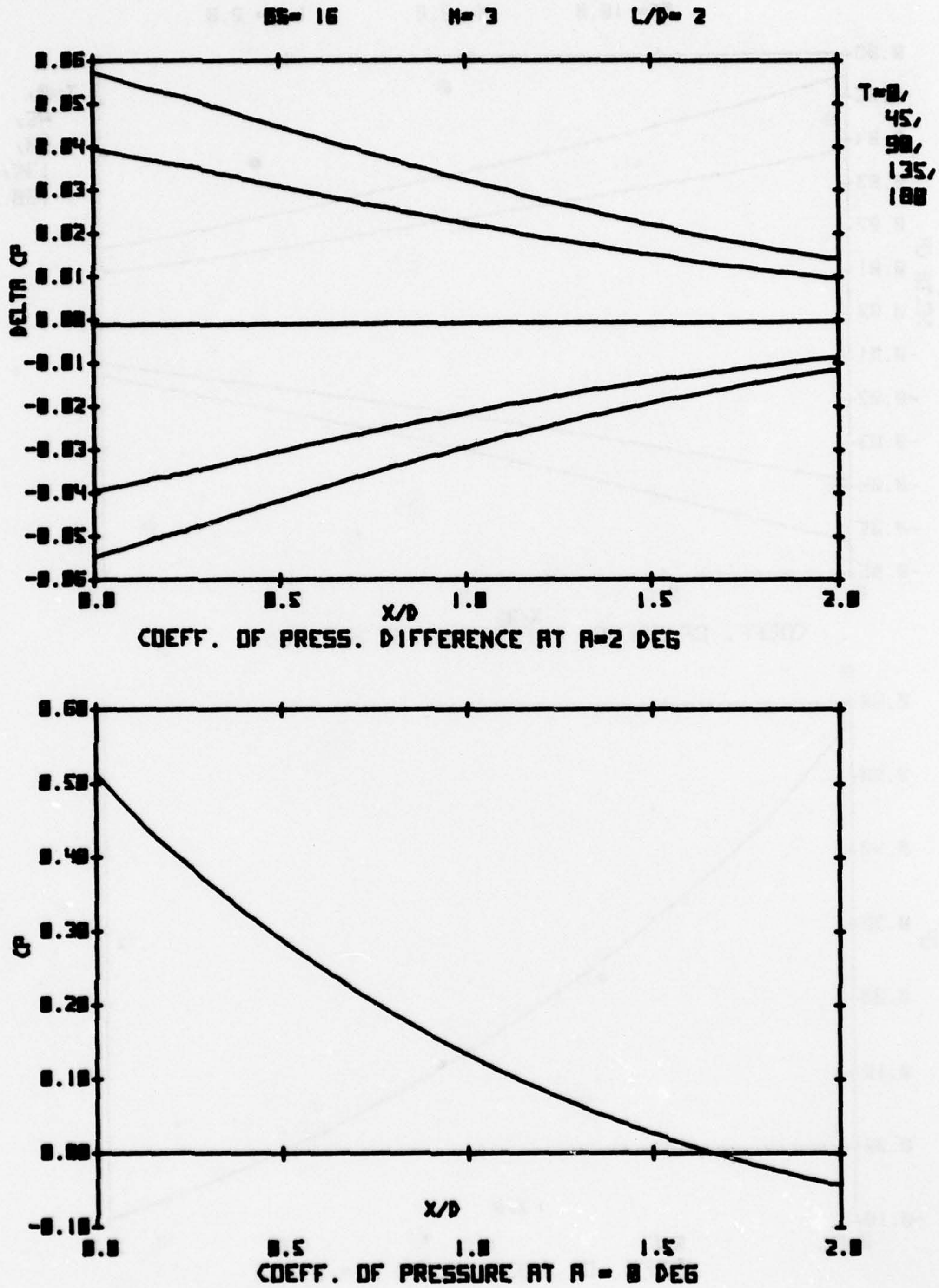


Figure 14. Surface pressure data versus axial direction (BS = 16, M = 2.5, L/D = 2).



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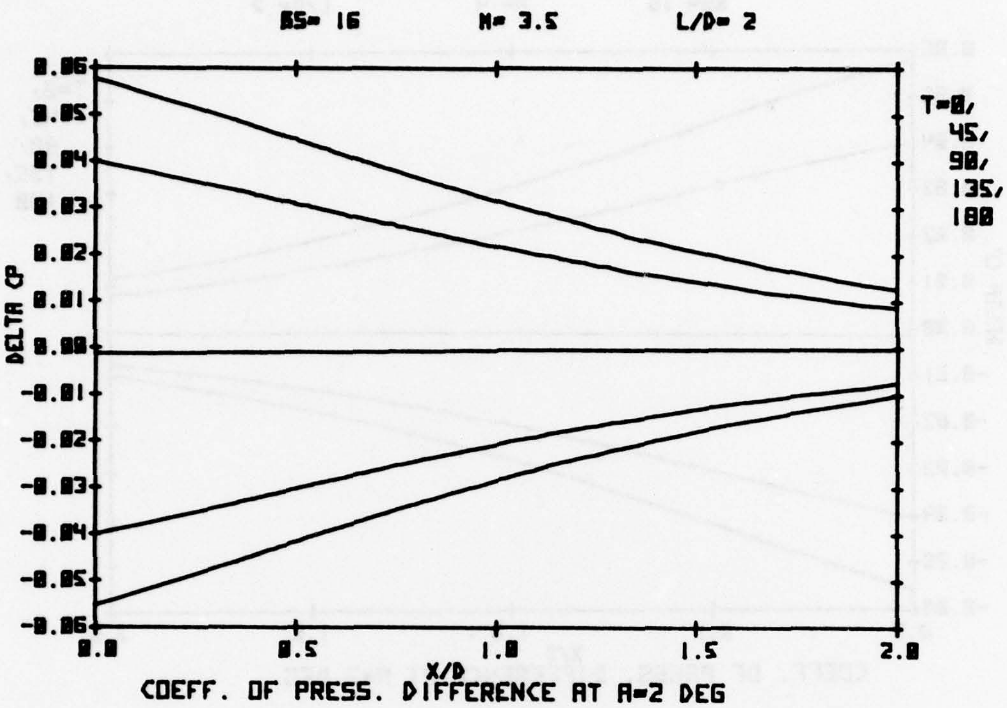


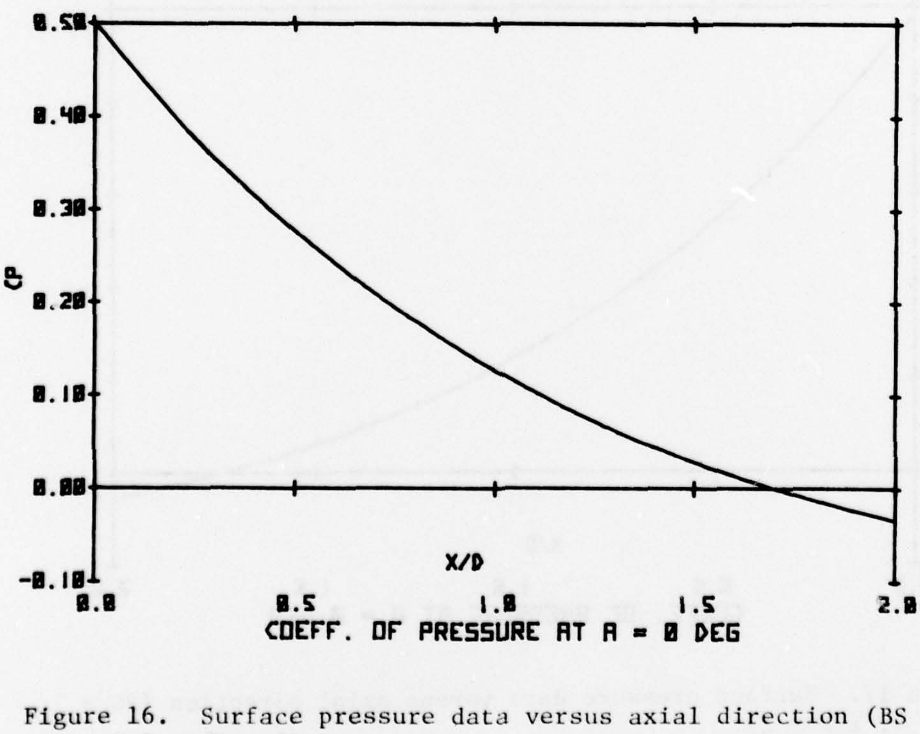
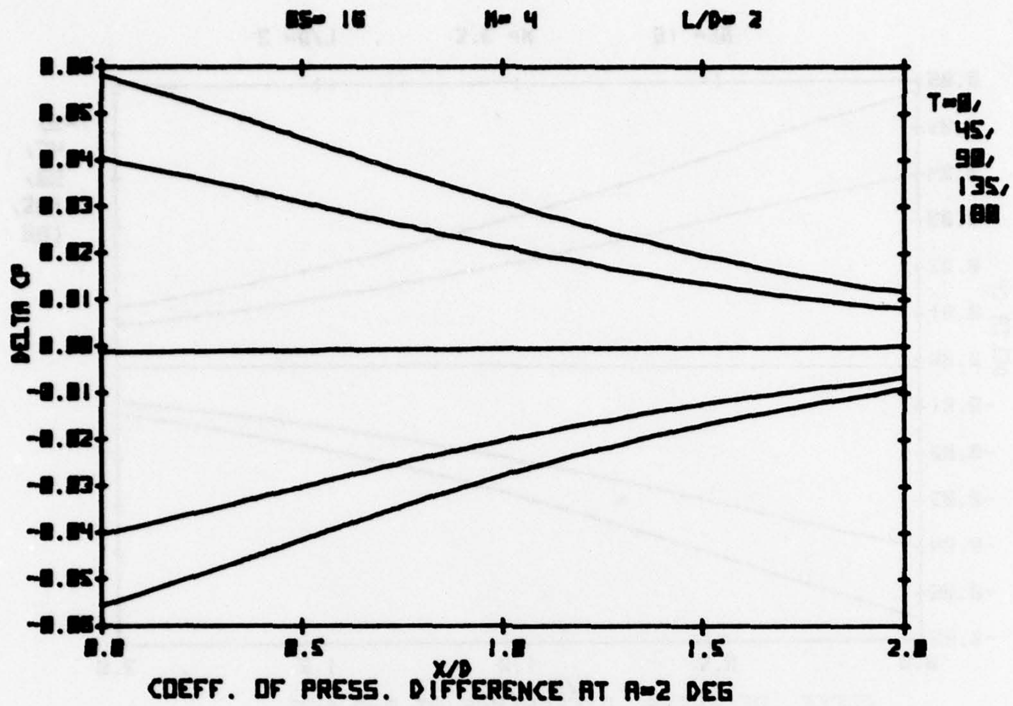


Figure 16. Surface pressure data versus axial direction (BS = 16, M = 3.5, L/D = 2).



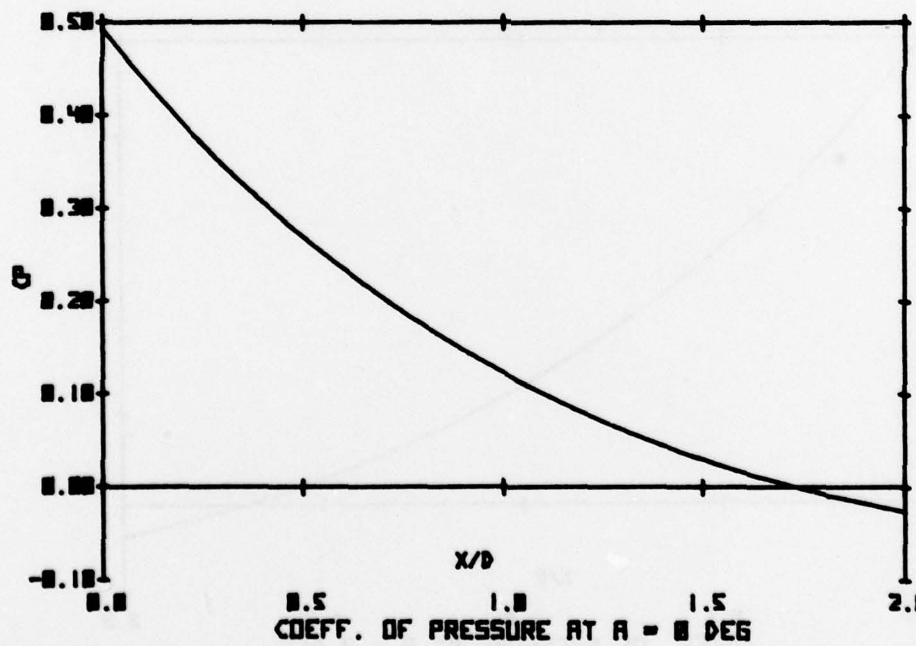
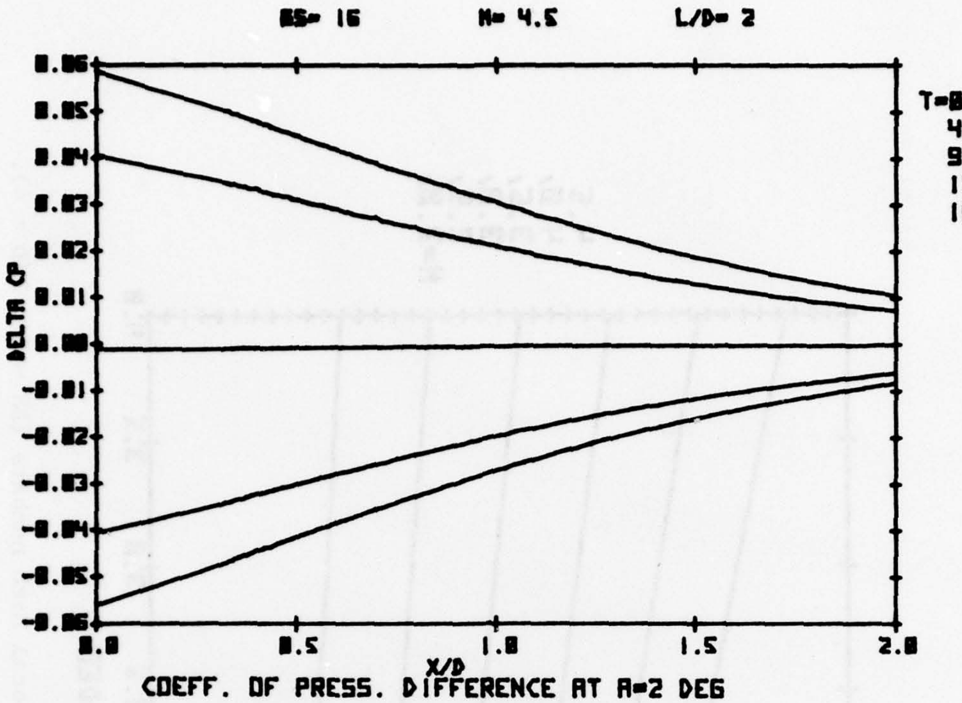


Figure 17. Surface pressure data versus axial direction (BS = 16, M = 4, L/D = 2).



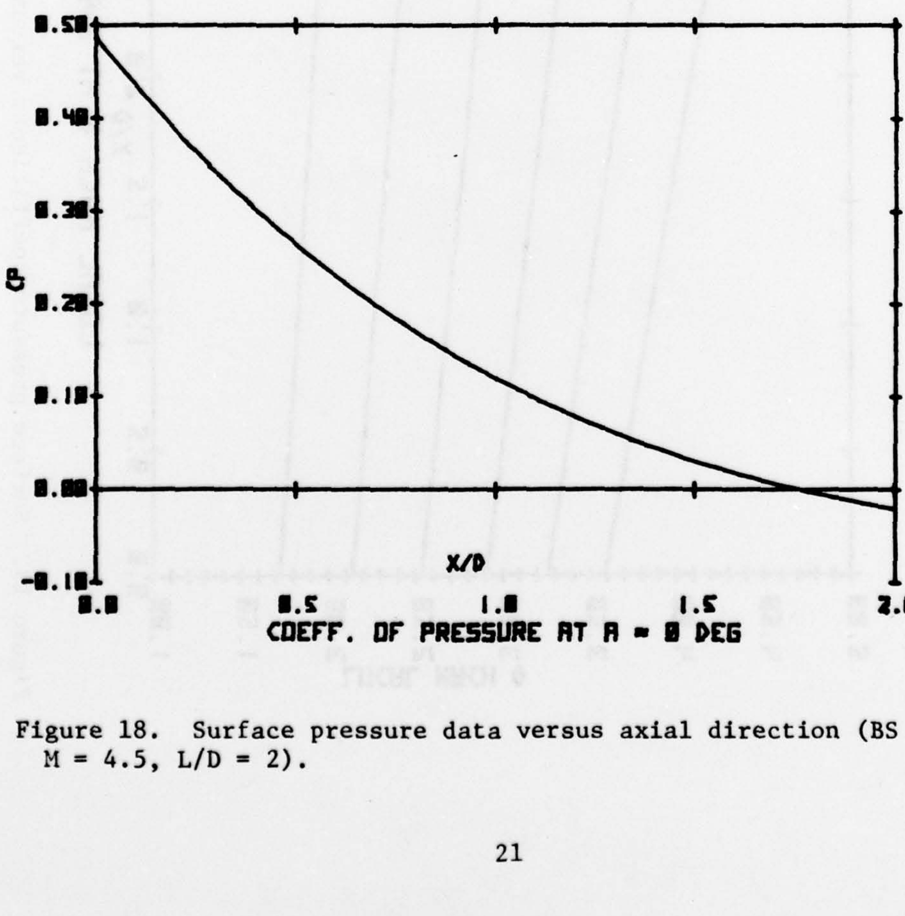


Figure 18. Surface pressure data versus axial direction (BS = 16, M = 4.5, L/D = 2).

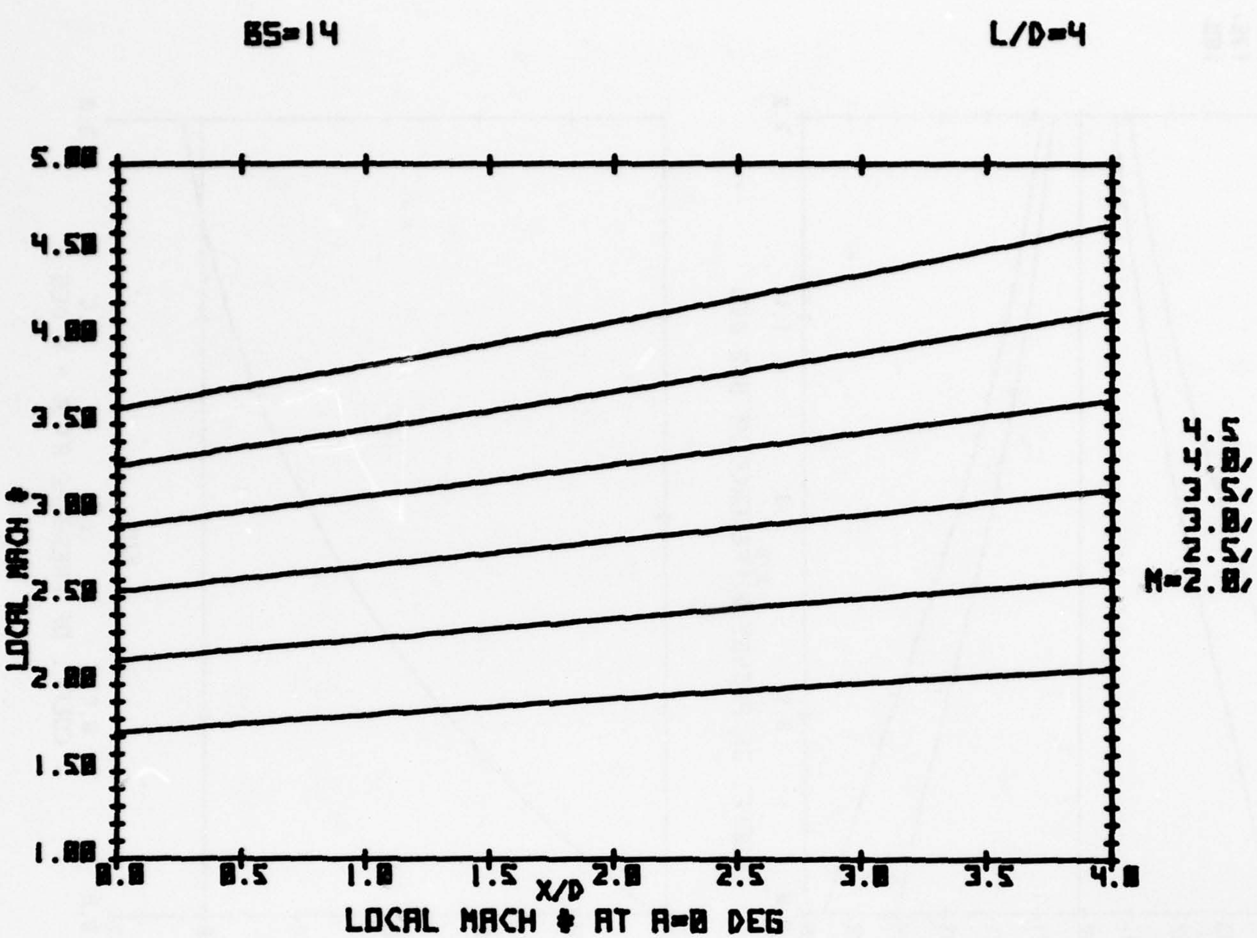


Figure 19. Surface pressure coefficients versus local Mach numbers (BS = 14, L/D = 4).

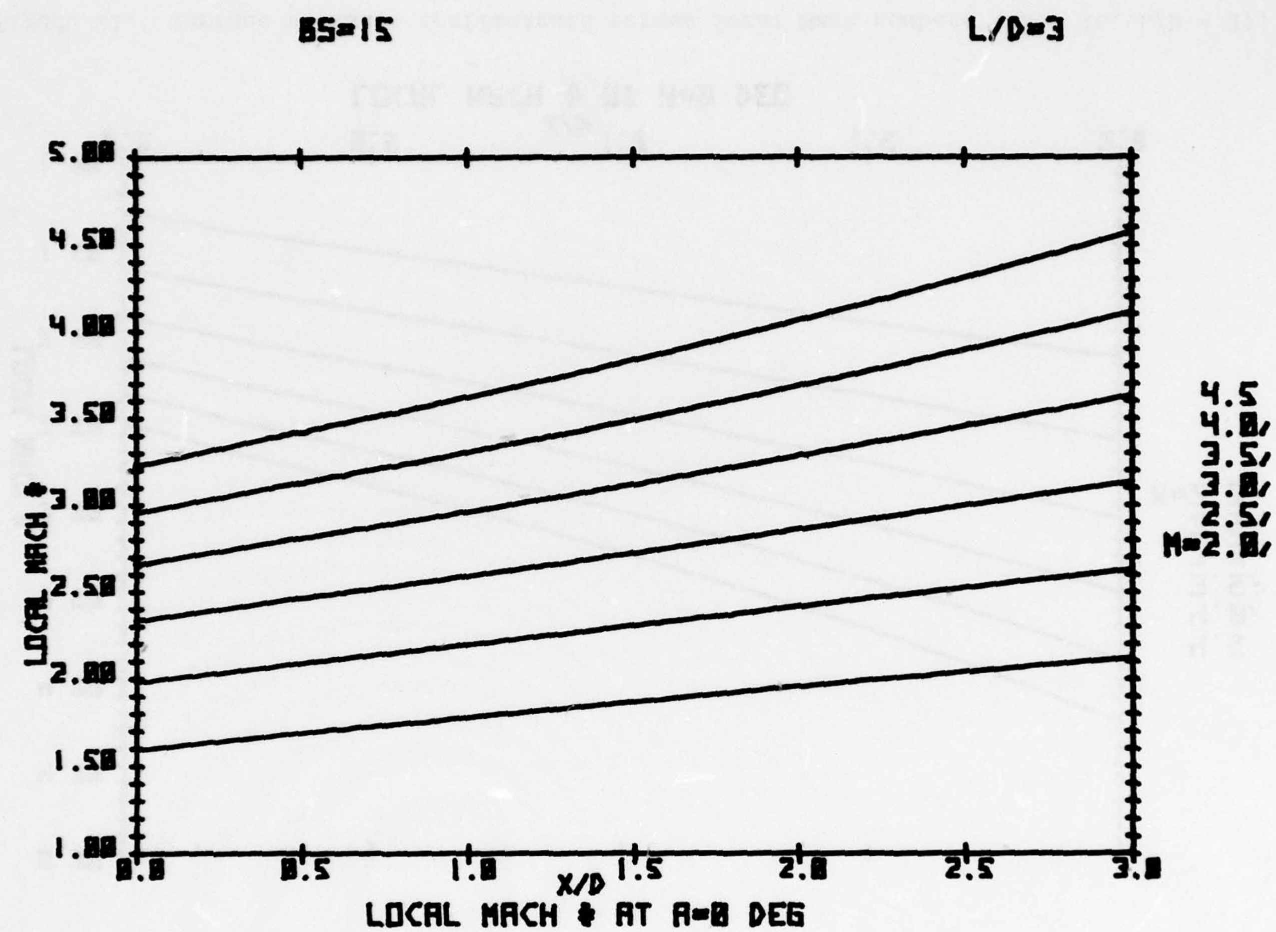


Figure 20. Surface pressure coefficients versus local Mach numbers (BS = 15, L/D = 3).

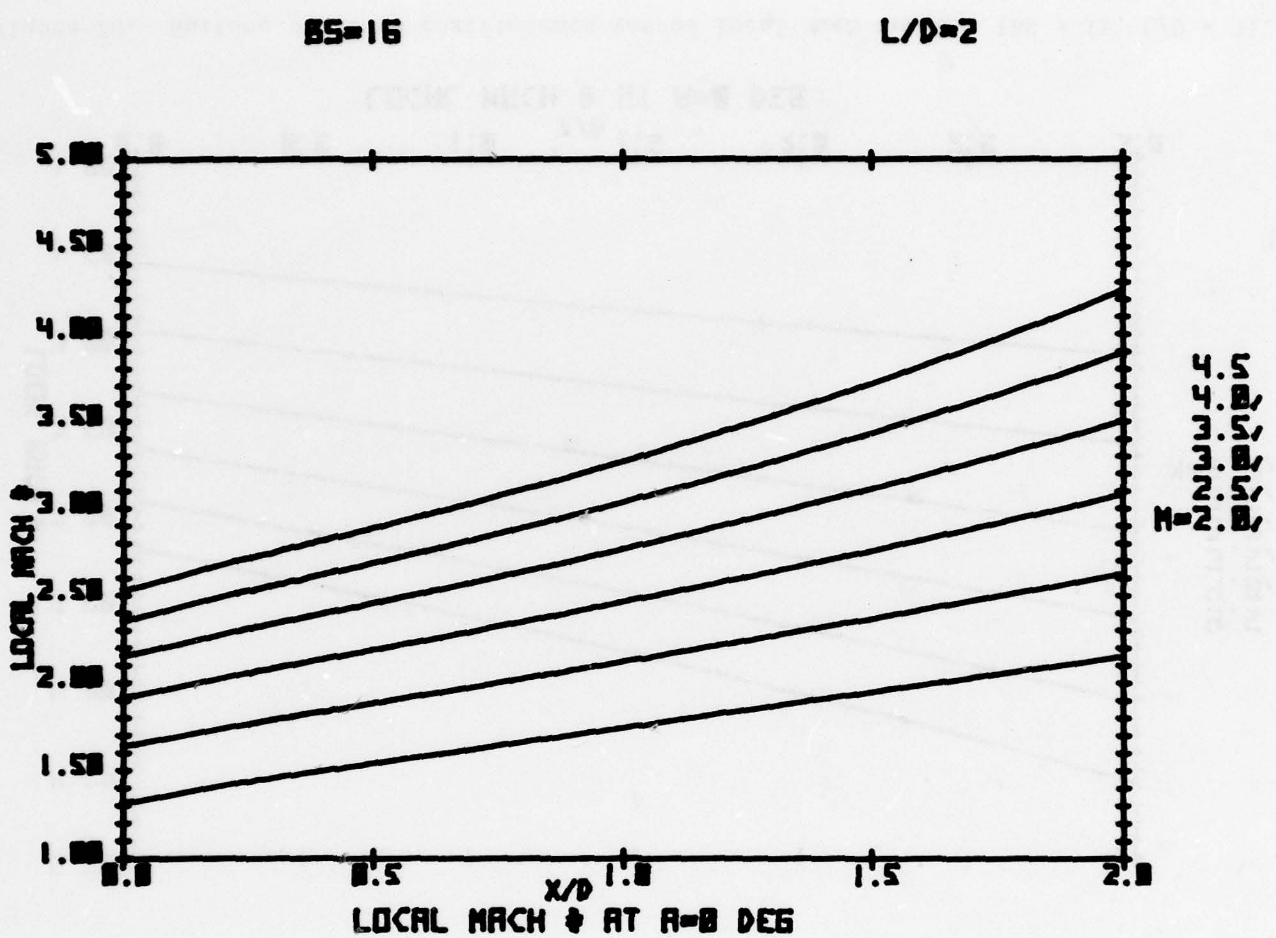


Figure 21. Surface pressure coefficients versus local Mach numbers (BS = 16, L/D = 2).

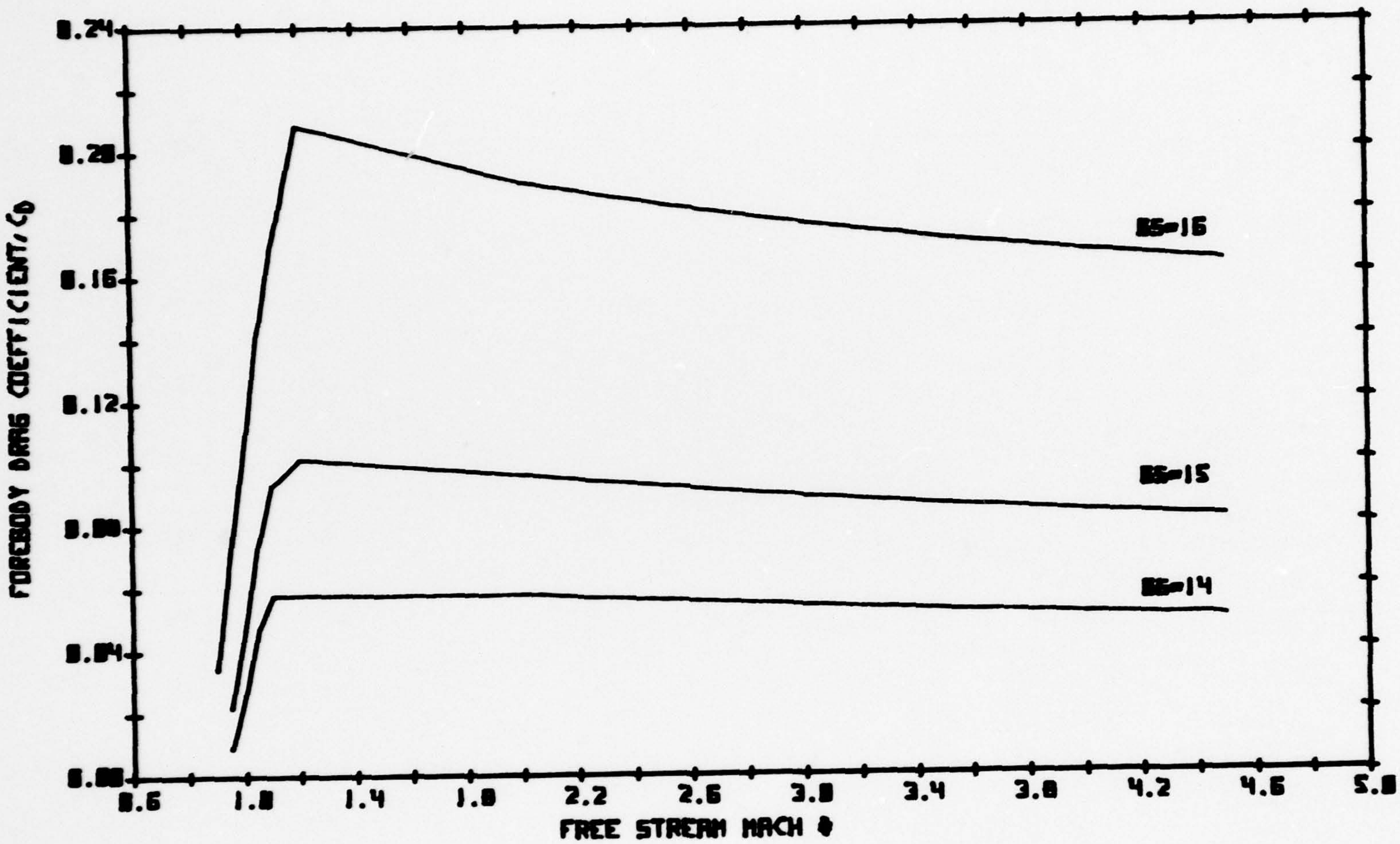


Figure 22. Forebody drag coefficient versus free stream Mach number at $\alpha = 0°$.

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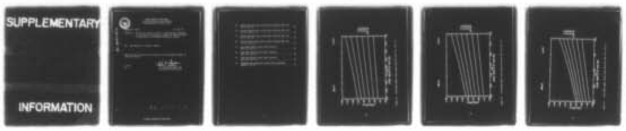

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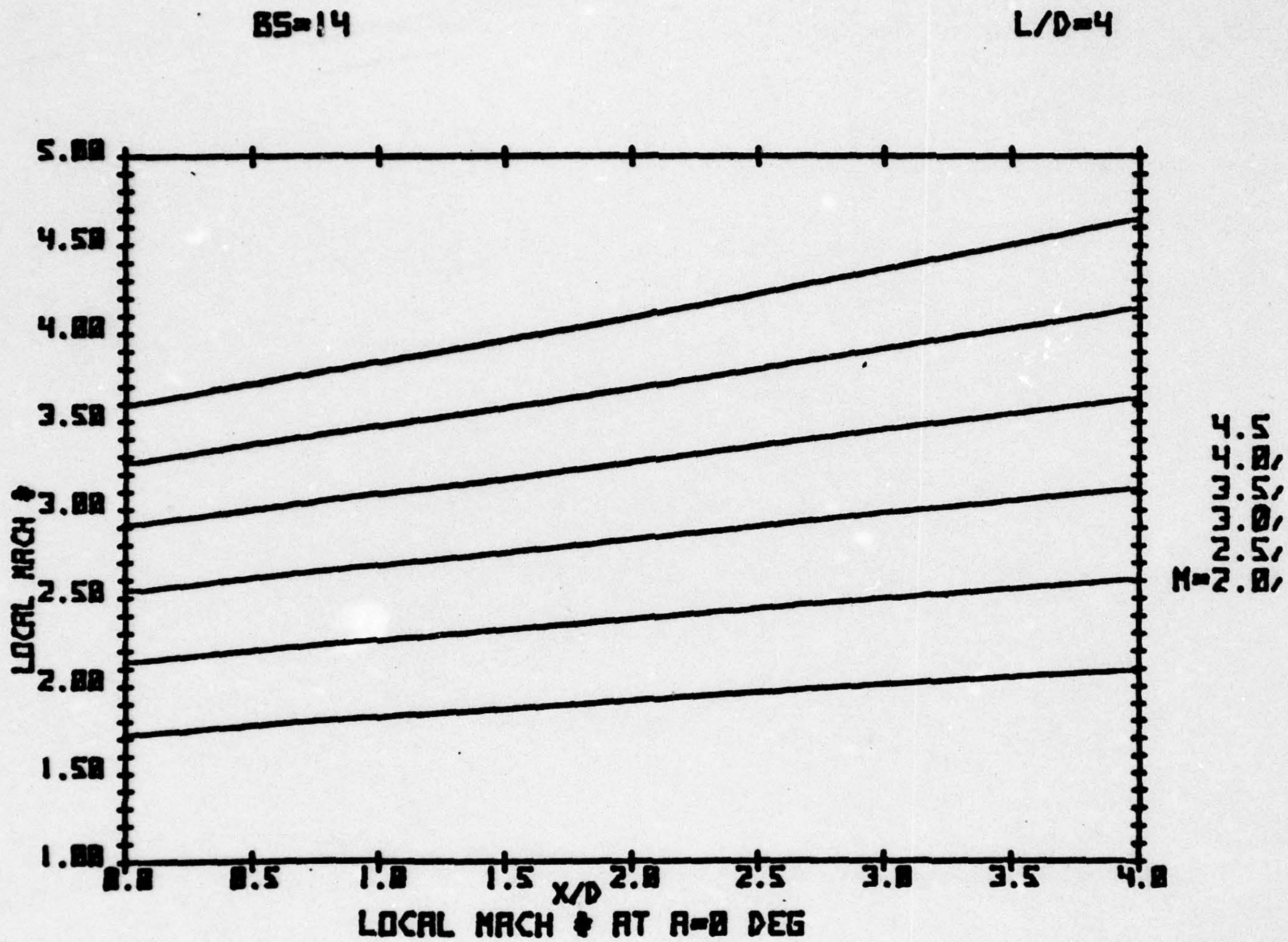

Figure 19. Local Mach number versus axial direction (BS = 14, L/D = 4).

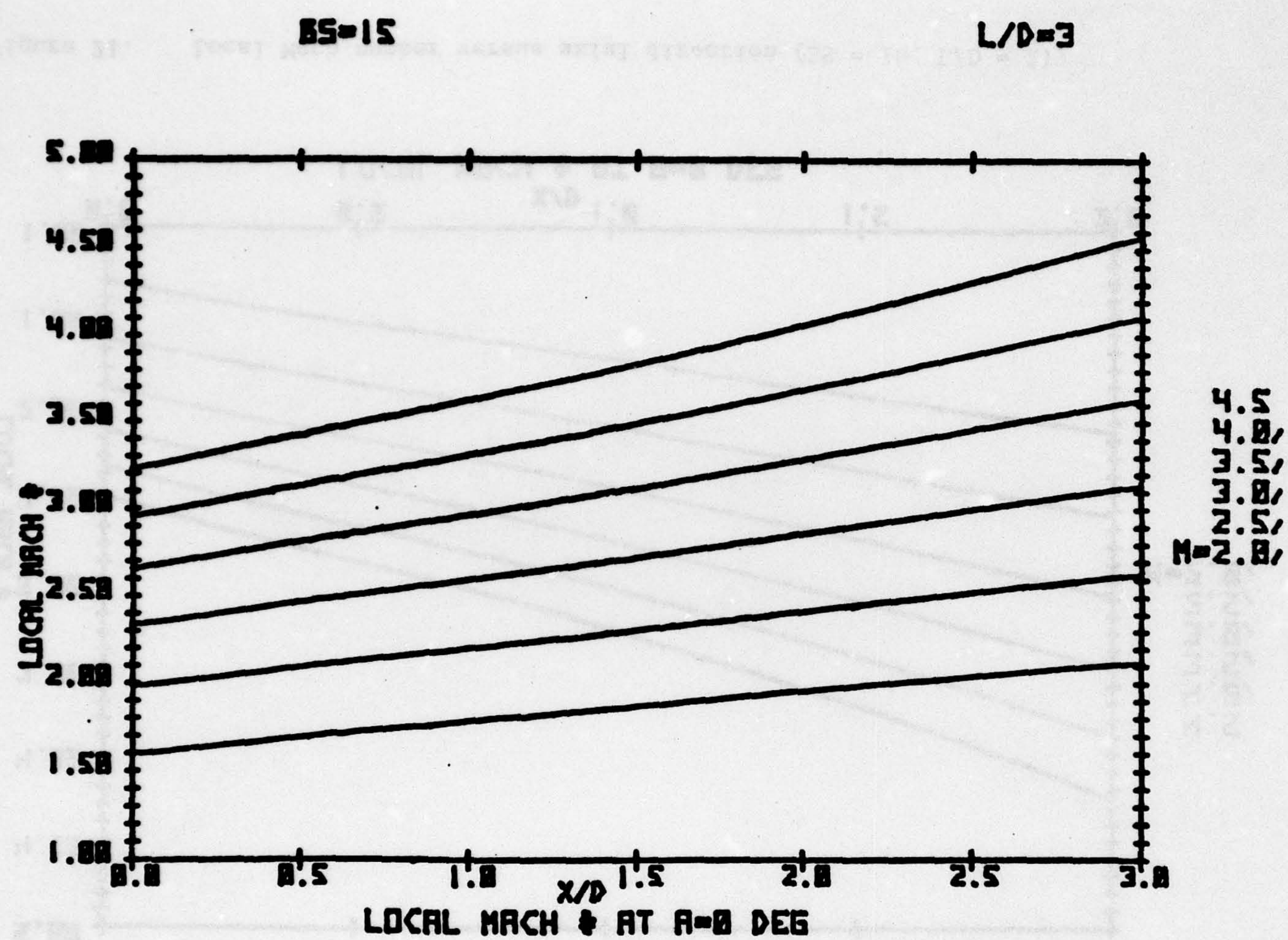

Figure 20. Local Mach number versus axial direction (BS = 15, L/D = 3).

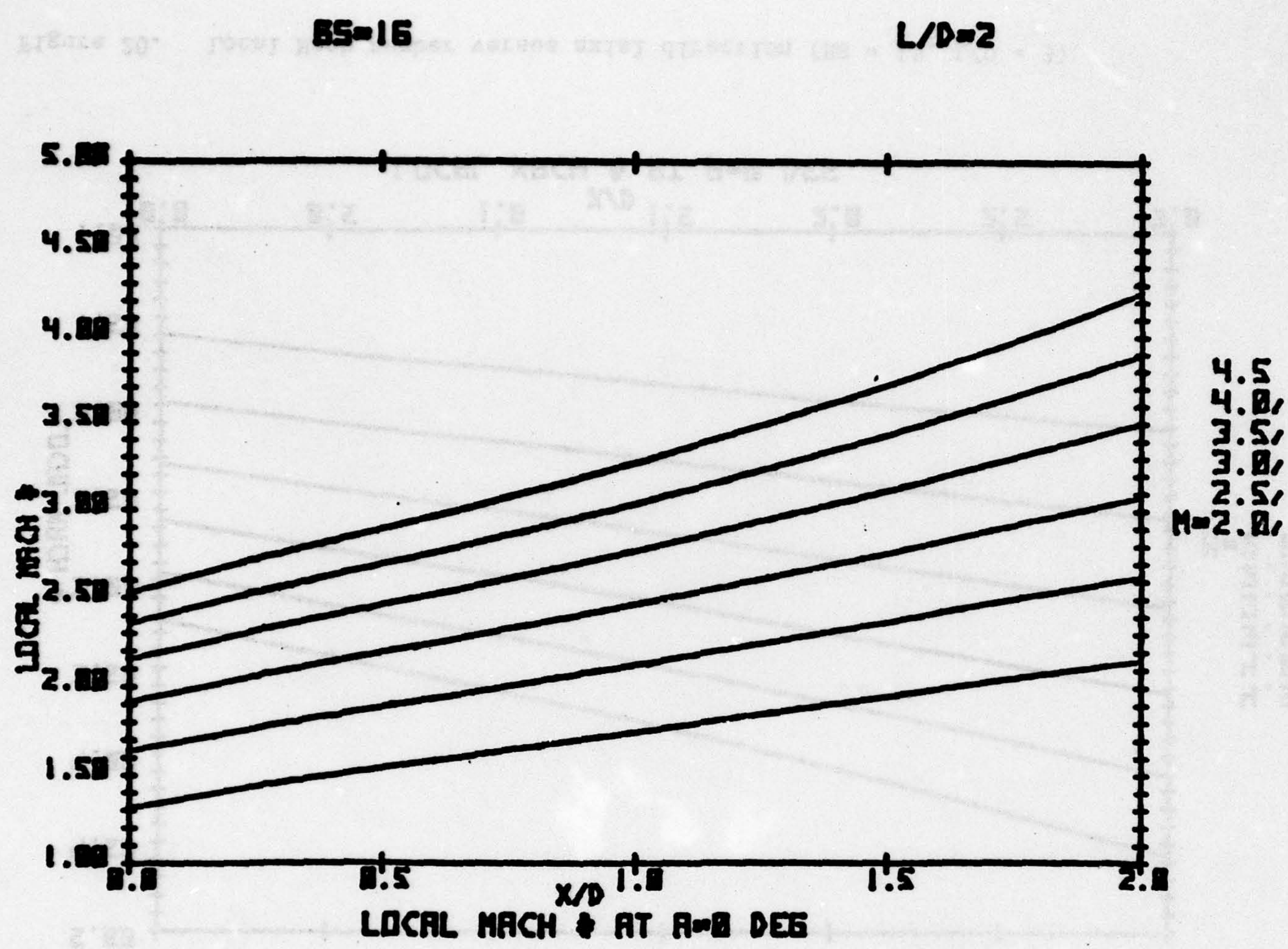

Figure 21. Local Mach number versus axial direction (BS = 16, L/D = 2).