



Градјевински факултет, Универзитет у Београду

Докторске студије 2017/18

Одсек за хидротехнику и водно – еколошко инжењерство

Механика флуида, напредни курс

Modeliranje turbulencije u pravougaonom kanalu primenom softvera iRIC - NaysCUBE

Kandidat:

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Sadržaj:

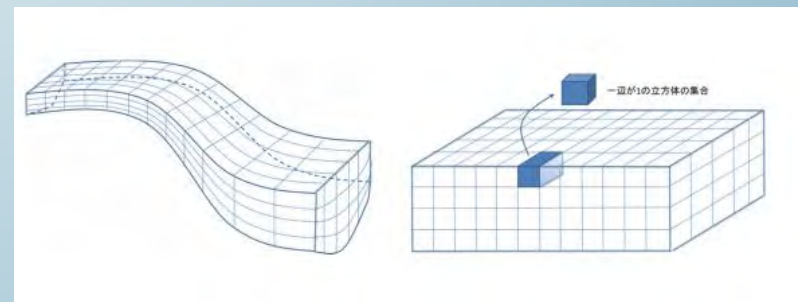
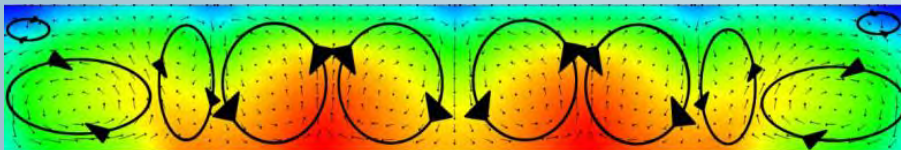
- *iRIC, NaysCUBE*
- *Zadatak modeliranja*
- *Kreiranje mreže*
- *Zadavanje parametara*
- *Zadavanje vremenskih parametara*
- *Zadavanje prepreke*
- *Rezultati*
- *Druga verijanta modela*
- *Nelinearni proračun drugog modela*
- *Zaključak*



iRIC, NaysCUBE:

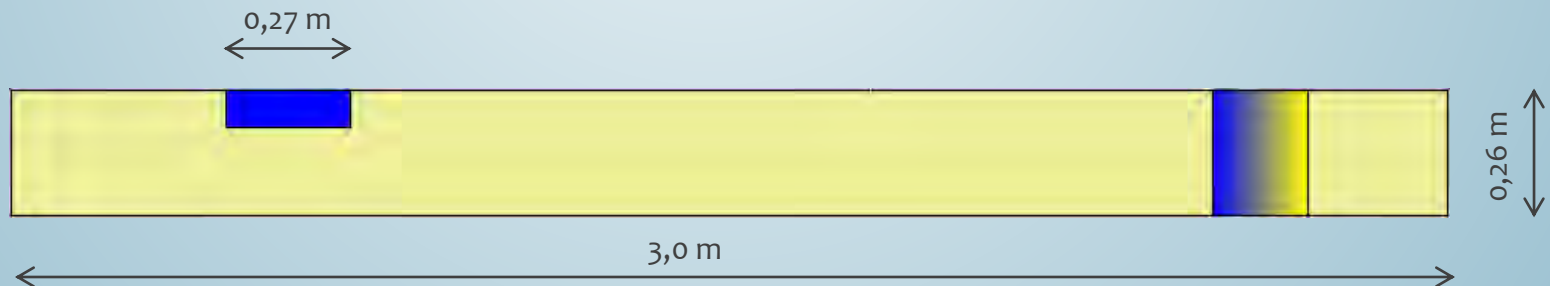
- *je solver za proračun trodimenzionalnog tečenja u otvorenim tokovima i za proračune deformacija rečnog korita*
- *simulira i sekundarna strujanja, opstrujavanje oko objekata u tokovima,...*
- *može da simulira tečenje u tokovima sa ili bez prepreka*
- *je pogodan za simulaciju ograničenog dela reke zbog detaljnije analize, ne i za simulaciju celog širokog područja reke*
- *koristi opšti krivolinijski koordinatni sistem koji kompleksnu rečnu sliku prebacuje u sistem kockica*

- *može da simulira različite hidrauličke veličine u 3D prikazu, kao što su: brzina vode, dubina vode, protok, nivo vode, srujnice, ...*
- *kao ulazne parametre zahteva protok vode, nivo vode na nizvodnom kraju deonice, Manningov koeficijent hrapavosti,...*



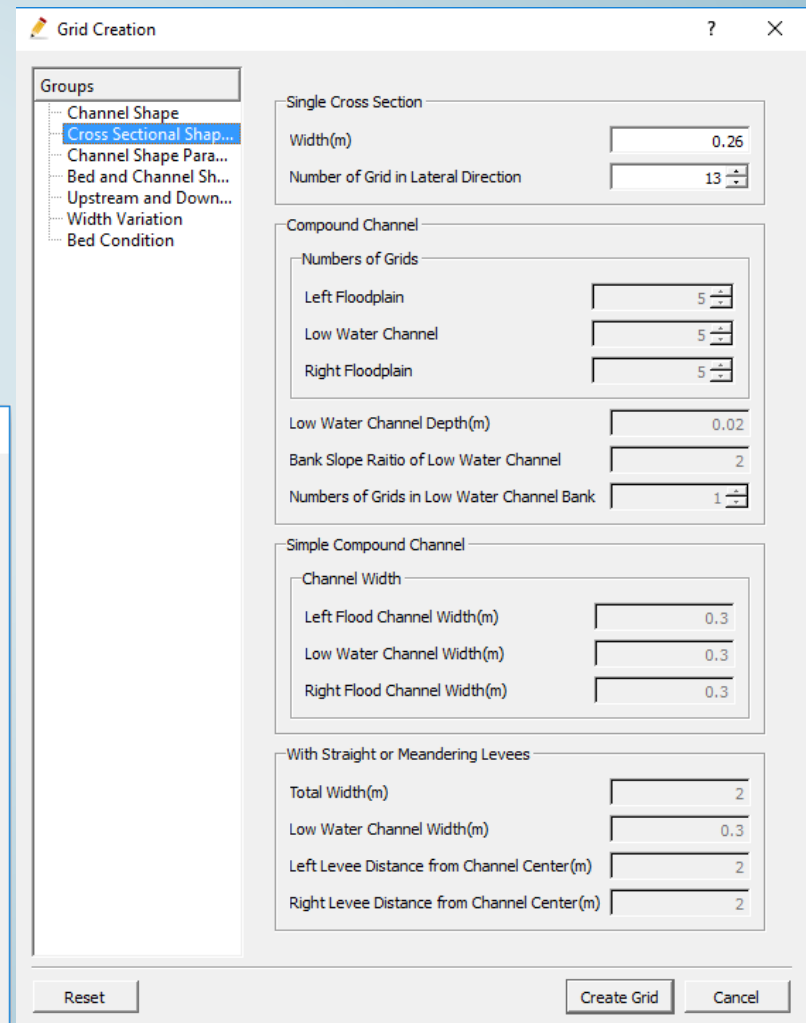
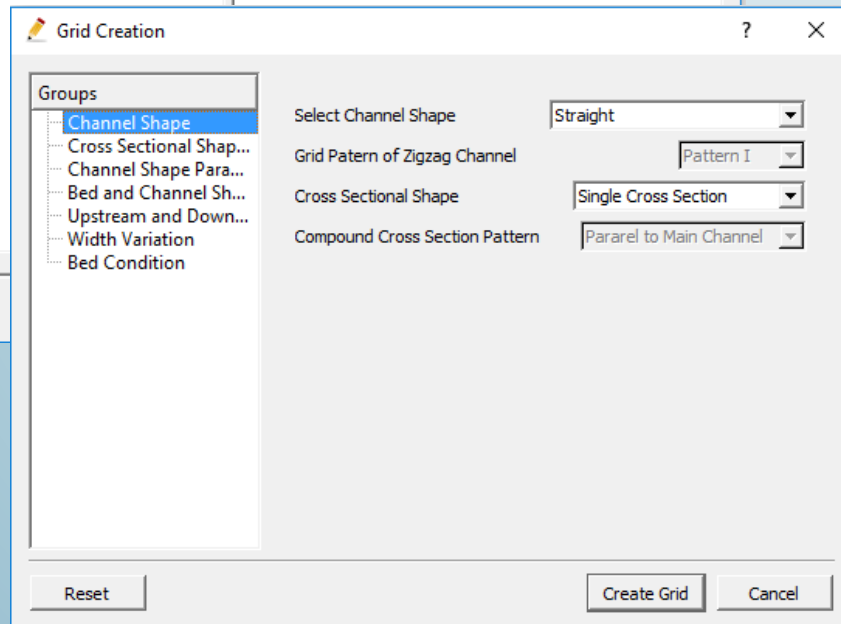
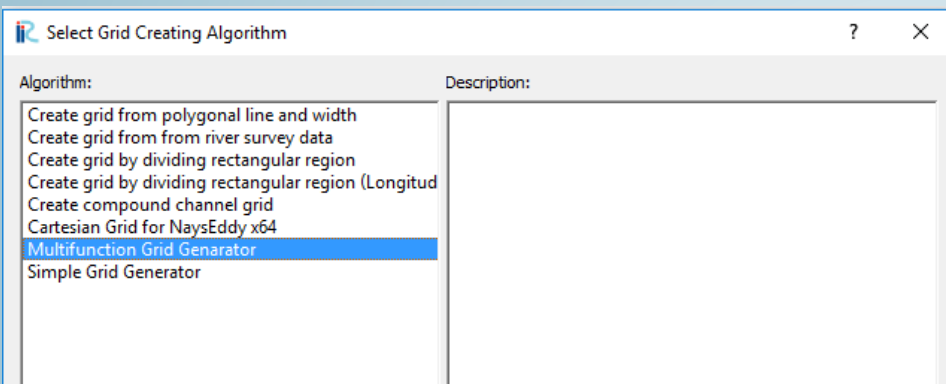
Zadatak modeliranja:

- Modelirati pravougaoni kanal konstantnog poprečnog preseka
- Širina dna kanala - 0,26 m.
- Dužina kanala – 3,0 m
- Grid mreža - $\Delta y = 0,02$ m
- Prepreka uz levu ivicu kanala
 - širina 30% širine kanala
 - dužina 1,5-2,0 * 70% širine kanala
- Preliv na nizvodnom kraju kanala
- Prilikom zadavanja parametara, $Fr =$ od 0,7 do 0,75



Kreiranje mreže:

- *Grid Creating Algorithm – Multifunction Grid Generator*
- *Pravolinijski kanal*
- *Poprečni presek jednak duž kanala*
- *Širina kanala 0,26m*
- *Broj podeoka grid mreže u y pravcu - 13*



Kreiranje mreže:

- Dužina kanala – 3m
- Broj podeoka grid mreže u x pravcu - 100
- Nagib dna kanala 0,001 (0,1%)

Groups

- Channel Shape
- Cross Sectional Shape Para...
- Channel Shape Parameters**
- Bed and Channel Shape
- Upstream and Downstream...
- Width Variation
- Bed Condition

Wave Length of Meander(m)

Wave Number

Meander Angle(degree)

Number of Grids in One Wave Length

Levee Meander Parameters

Meander Angle(degree)

Meander Wave Length(m)

Phase Lag from LWC(m)

Kinoshita Meander Parameters

Additional Meander Angle(degree)

n1(Wave Number of the second term)

Reset Create Grid Cancel

Groups

- Channel Shape
- Cross Sectional Shape P..
- Channel Shape Parame...
- Bed and Channel Shape**
- Upstream and Downstr...
- Width Variation
- Bed Condition

Initial Bed Shape

Bar Height or Amplitude of Parabolic Shape(m)

Lag Between Bar and Plane Geometry(m)

Channel Slope

Reset Create Grid Cancel

Kreiranje mreže:

- Bez dodatog uzvodnog i nizvodnog dela kanala
- Konstantna širina kanala
- Dno je fiksirano, sprečena mogućnost pomeranja

(Program ima i mogućnost proračuna pomeranja dna, ali u ovom slučaju, to nije tema zadatka)

Groups

- Channel Shape
- Cross Sectional Shap...
- Channel Shape Para...
- Bed and Channel Sh...
- Upstream and Down...**
- Width Variation
- Bed Condition

Add straight channel in upstream and downstream

Number of Adding Sections in Upstream End

Number of Adding Sections in Downstream End

Reset

Groups

- Channel Shape
- Cross Sectional Shape Parame...
- Channel Shape Parameters
- Bed and Channel Shape
- Upstream and Downstream C...
- Width Variation**
- Bed Condition

Width Variation

Width Variation Type

Width Deviation(m)

Reset

Groups

- Channel Shape
- Cross Sectional Shape Parameters
- Channel Shape Parameters
- Bed and Channel Shape
- Upstream and Downstream Con...
- Width Variation
- Bed Condition**

Low Water Channel

Bed Condition

Roughness Definition

Roughness Value

Floodplain

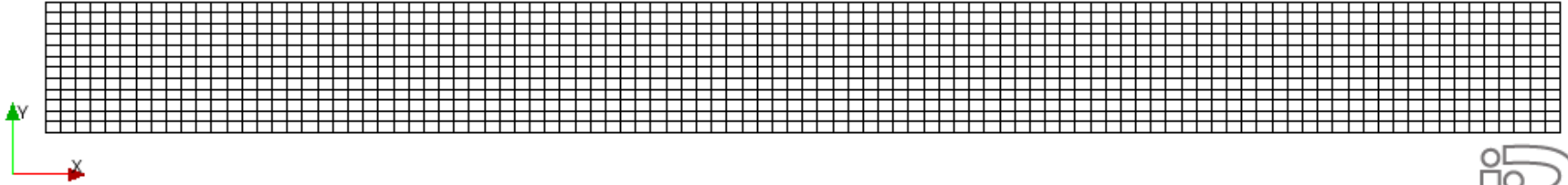
Bed Condition

Roughness Definition

Roughness Value

Reset

Kreiranje mreže:



- *Na slici - izgled kreirane mreže*
 - *Grid $\Delta x * \Delta y = 0,03 * 0,02$*
 - *Broj podeoka grid mreže $\Delta x * \Delta y = 100 * 13$*

Zadavanje parametara:

B = 0.260 m	B = 0.180 m	B = 0.180 m
g = 9.810 m/s ²	g = 9.810 m/s ²	g = 9.810 m/s ²
h = 0.276 m	h = 0.276 m	h = 0.310 m
cp = 0.490 -	cp = 0.490 -	cp = 0.490 -
Fr = 0.700 -	Fr = 1.011 -	Fr = 0.710 -
Hpr = 0.061 m	Q = 0.038 m ³ /s	Q = 0.038 m ³ /s
Hbet = 0.215 m		
Q = 0.038 m ³ /s		

- Iz Šezi-Maningove jednačine dobijen je protok u kanalu, kao i dubina vode uz pomoć funkcije Goal-Seek, tako da Frudov broj bude 0,7.
- Uslov Frudovog broja nije ispunjen za deo kanala na kome postoji prepreka, pa je na osnovu ovog dela kanala dobijena zahtevana dubina vode

- Zadatkom definisano:
 - Frudov broj (Fr)
 - Širina kanala (B)
 - Nagib dna kanala (I_d)
- Potrebno naći:
 - Protok (Q)
 - Dubinu vode (h)
 - Visinu preliva ($H=h-H_{pr}$)

$$Fr = \frac{Q B^2}{g A^3}$$

$$Q = \frac{1}{n} A R^{\frac{2}{3}} \sqrt{I_d}$$

$$H_{pr} = \left(\frac{Q}{C_p B \sqrt{2g}} \right)^{\frac{2}{3}}$$

$$C_p = 0,47 - 0,49$$

Zadavanje parametara:

- Broj podeoka mreže u vertikalnom pravcu – 18
- Linearni k-e model
- Protok $Q=0,0375 \text{ m}^3/\text{s}$
- Nizvodni granični uslov, $h=0,31 \text{ m}$
- Manningov koeficijent hrpavosti kanala $n=0,012$

Calculation Condition

Groups

- Basic Parameters
- Time Conditions
- Flow Conditions
- Roughness Conditions
- Bed Conditions
- Vegetation Conditions
- Boundary conditions
- Hot start conditions
- Additional output files
- Initial topography correction
- DriftWood
- Advanced settings

Number of Vertical Layers: 18

Fixed or Movable Bed: Fixed bed

Turbulence Model: Linear k-e model

Spatial Scheme for Advection Terms: TVD MUSCL

Reset

Calculation Condition

Groups

- Basic Parameters
- Time Conditions
- Flow Conditions
- Roughness Conditions
- Bed Conditions
- Vegetation Conditions
- Boundary conditions
- Hot start conditions
- Additional output files
- Initial topography cor...
- DriftWood
- Advanced settings

Discharge[m3/s]: 0.0375

How to give outlet water level?: Given directly

Downstream Water Level[m]: 0.31

Minimum Depth[m]: 0

How to give initial surface slope?: Given by initial average bed slope

Initial surface slope: 0.0001

Q gradual increase: Q given directly

Initial Q rate: 0.1

Time for Q slope[s]: 10

Save and Close Cancel

Calculation Condition

Groups

- Basic Parameters
- Time Conditions
- Flow Conditions
- Roughness Conditions
- Bed Conditions
- Vegetation Conditions
- Boundary conditions
- Hot start conditions
- Additional output files
- Initial topography correction
- DriftWood
- Advanced settings

How to evaluate u^* at BED?: Manning Law

Manning n for zone A: 0.012

Manning n for zone B: 0.012

Manning n for zone C: 0.012

Manning n for zone D: 0.012

Manning n for zone E: 0.012

How to calculate u^* at WALL?: Manning Law

Manning n for WALL: 0.012

Manning n for obstacle: 0.012

Reset

Save and Close Cancel

Zadavanje vremenskih parametara:

– Prva verzija

Parameter	Value
Start Time[s]	0
End Time[s]	90
File Output Time[s]	0.5
Time Step[s]	0.0001
Start time of surface move[s]	0.5
Start time of bed move[s]	2

- Laptop nije bio dovoljno jak za ovaj proračun, ispustio je dušu nakon tri dana proračuna

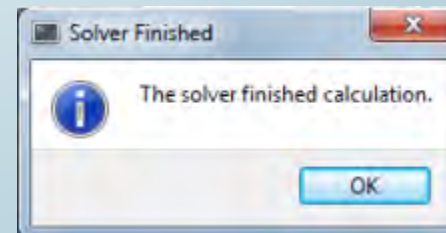
Urađene su različite varijante i zaključeno je da se za $\Delta t > 0,005$ dobija nestabilan proračun.

```
Q takes NaN value! Check dt and other conditions !  
We suspend computation !!  
Fortran Pause - Enter command<CR> or <CR> to continue.
```

– Druga verzija - usvojena

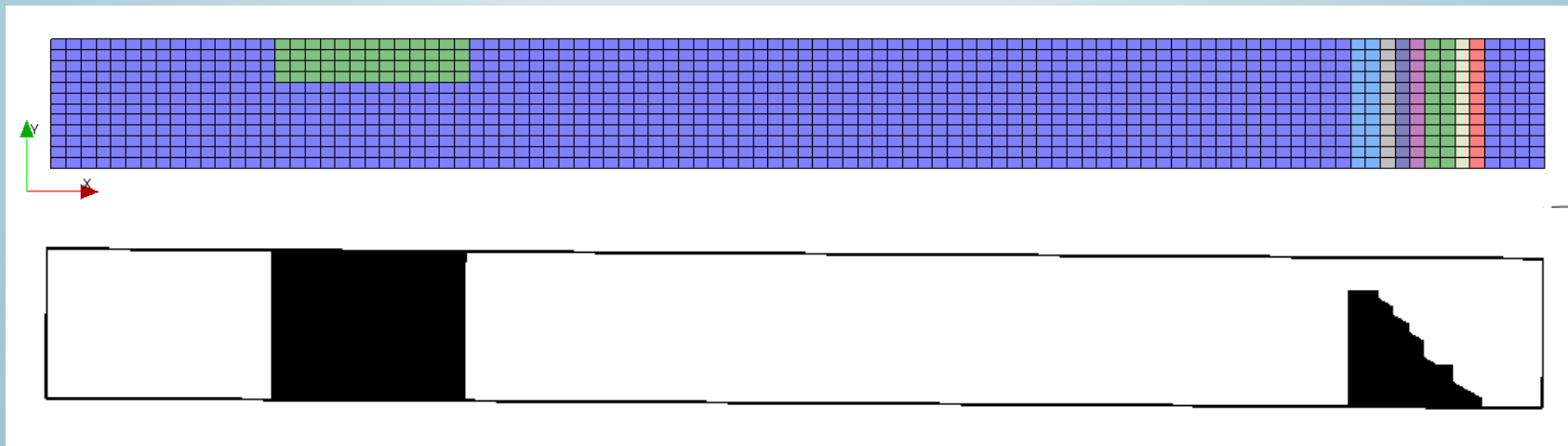
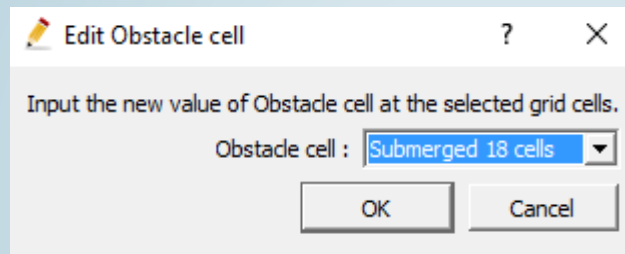
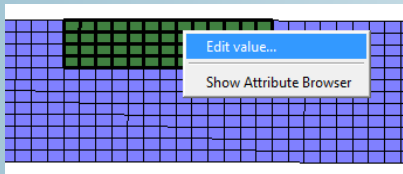
Parameter	Value
Start Time[s]	0
End Time[s]	20
File Output Time[s]	0.5
Time Step[s]	0.001
Start time of surface move[s]	0.5
Start time of bed move[s]	2

- Proračun je završen i stabilan – nema potrebe za dodatnim smanjenjem računskog koraka



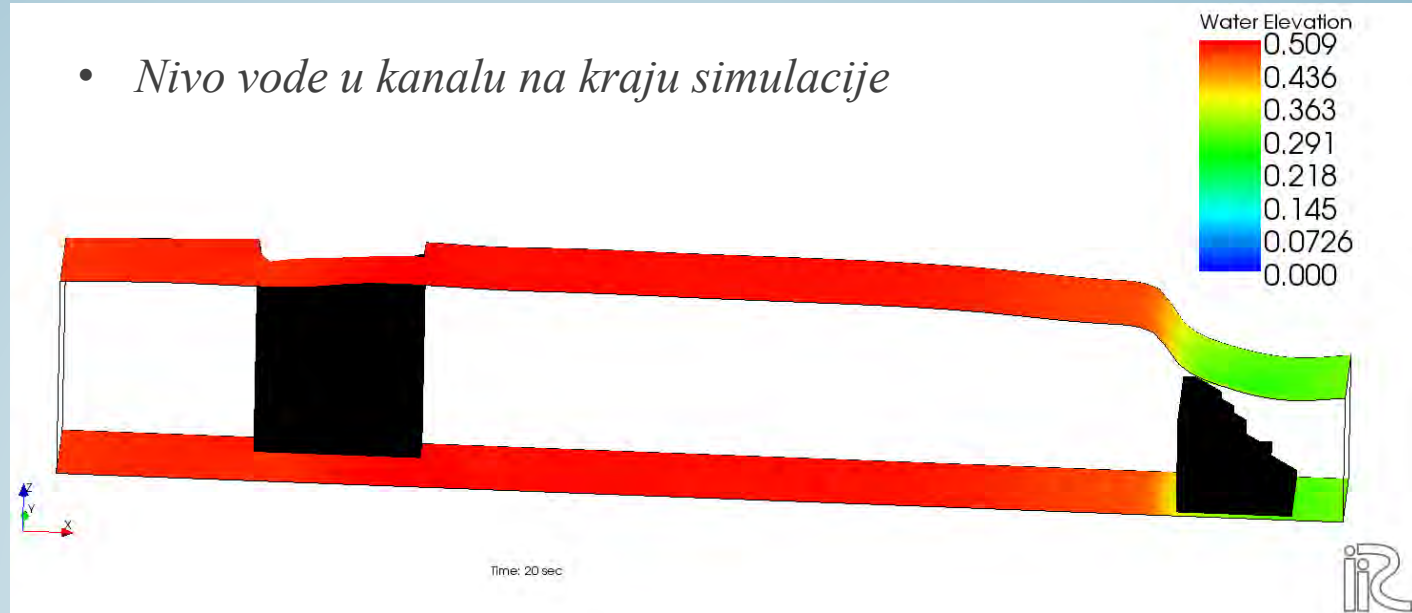
Zadavanje prepreka:

- *Cell attributes / Obstacle cell*
- *Prepreka – submerged 18 cells – visina prepreke ista kao dubina vode*
- *Preliv – stepenasti, visina preлива – submerged 14 cells*
- *Na slici – osnova i presek kanala nakon zadatih prepreka*

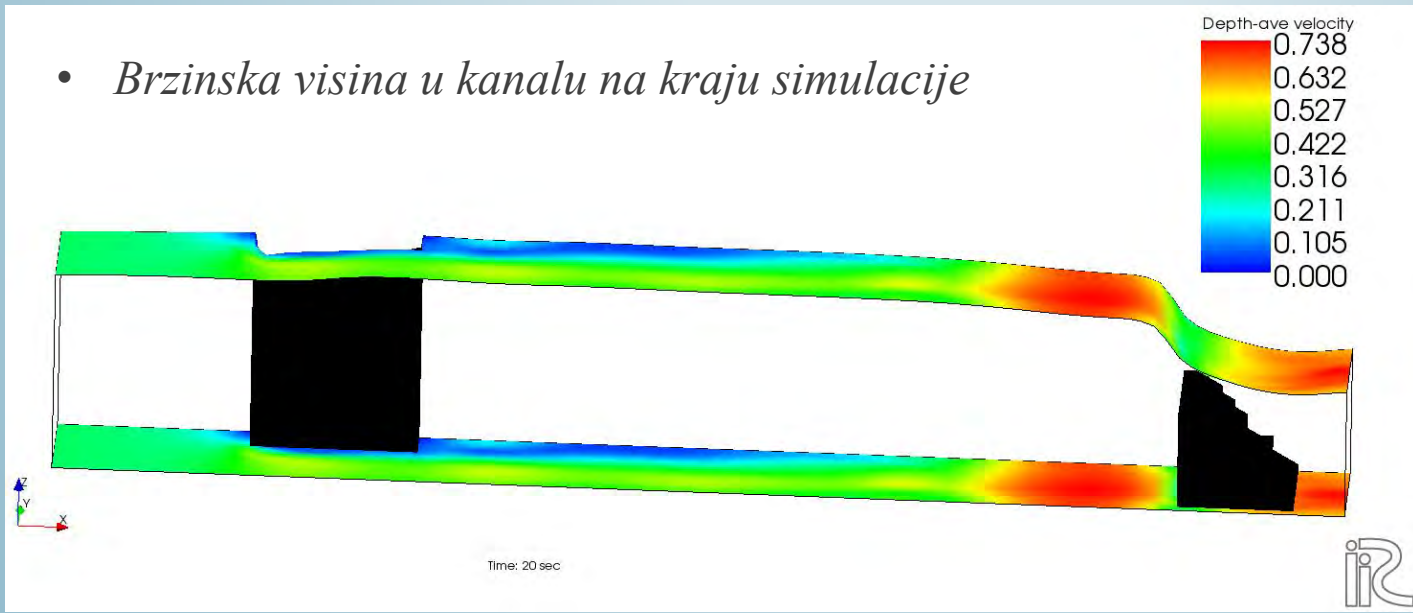


Rezultati:

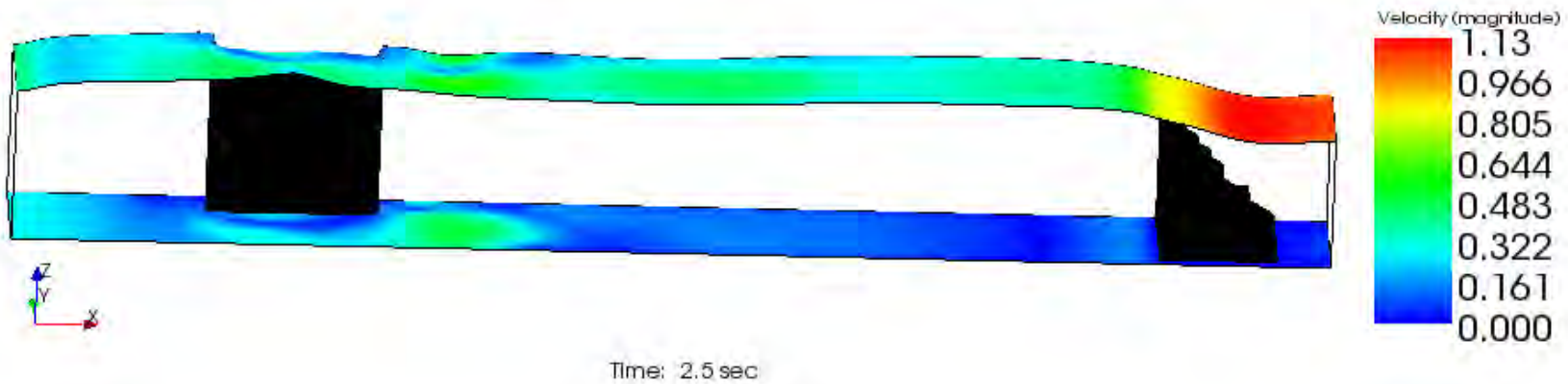
- *Nivo vode u kanalu na kraju simulacije*



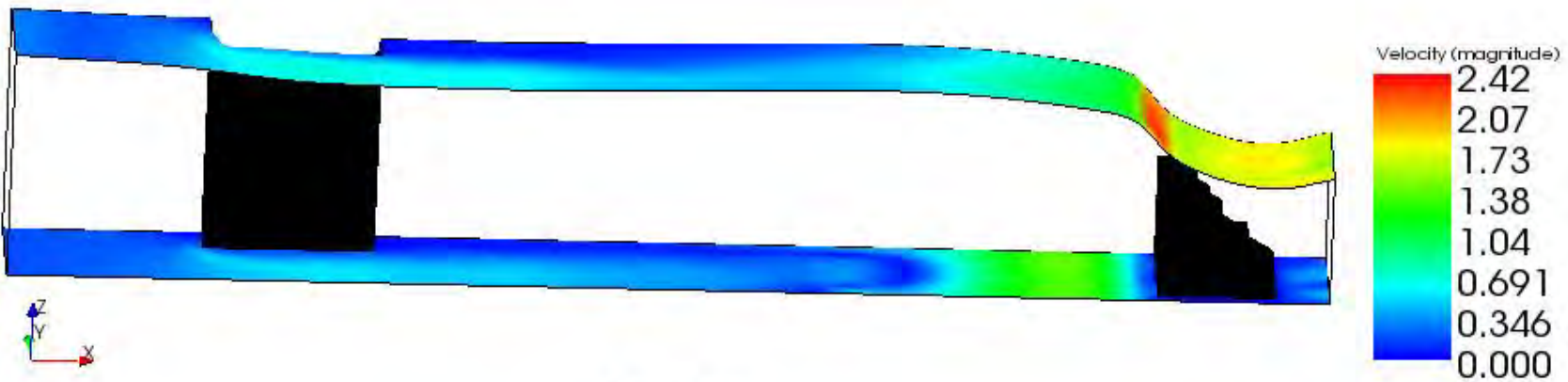
- *Brzinska visina u kanalu na kraju simulacije*



Rezultati:

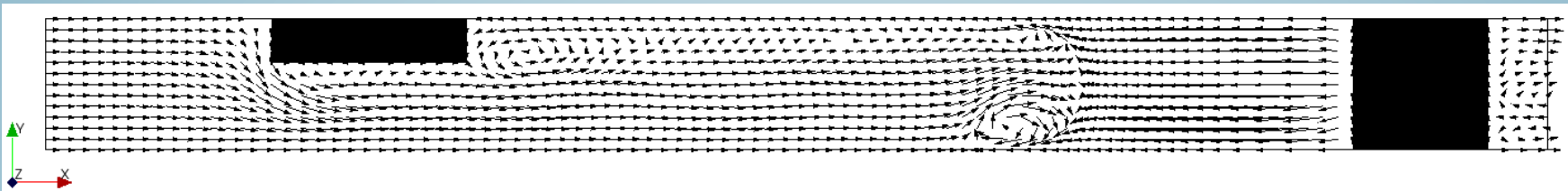


- *Brzina vode u kanalu nakon 2,5 s simulacije*

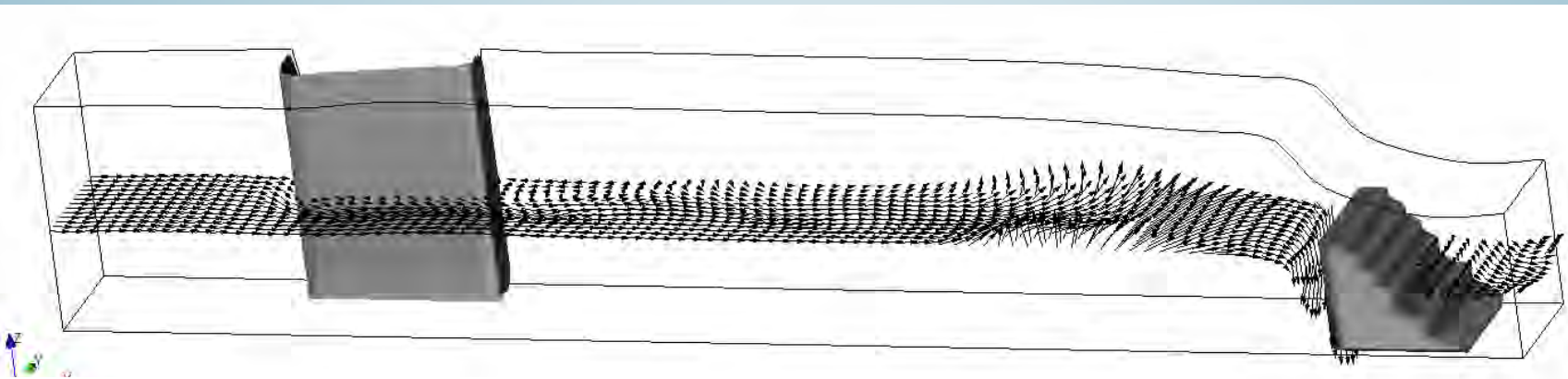
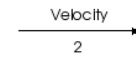


- *Brzina vode u kanalu na kraju simulacije*

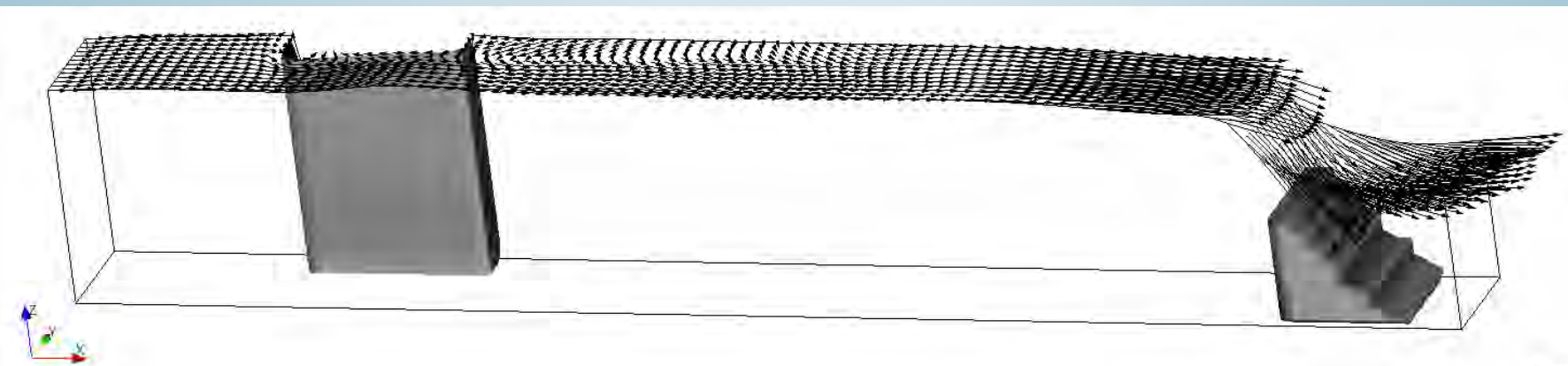
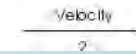




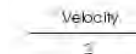
- *Kretanje vode po dnu kanala na kraju simulacije*

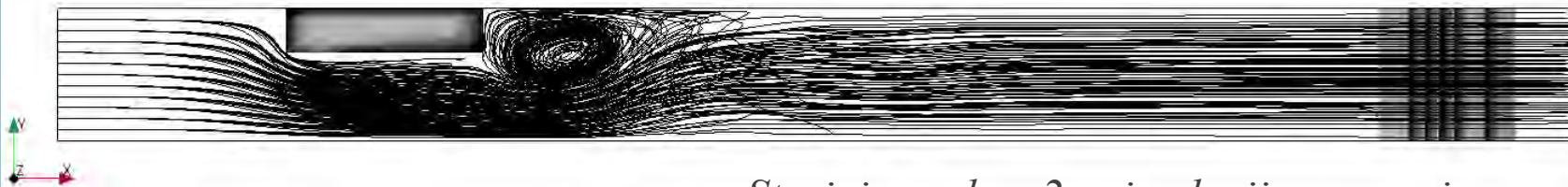


- *Kretanje vode po sredini dubine vode na kraju simulacije*



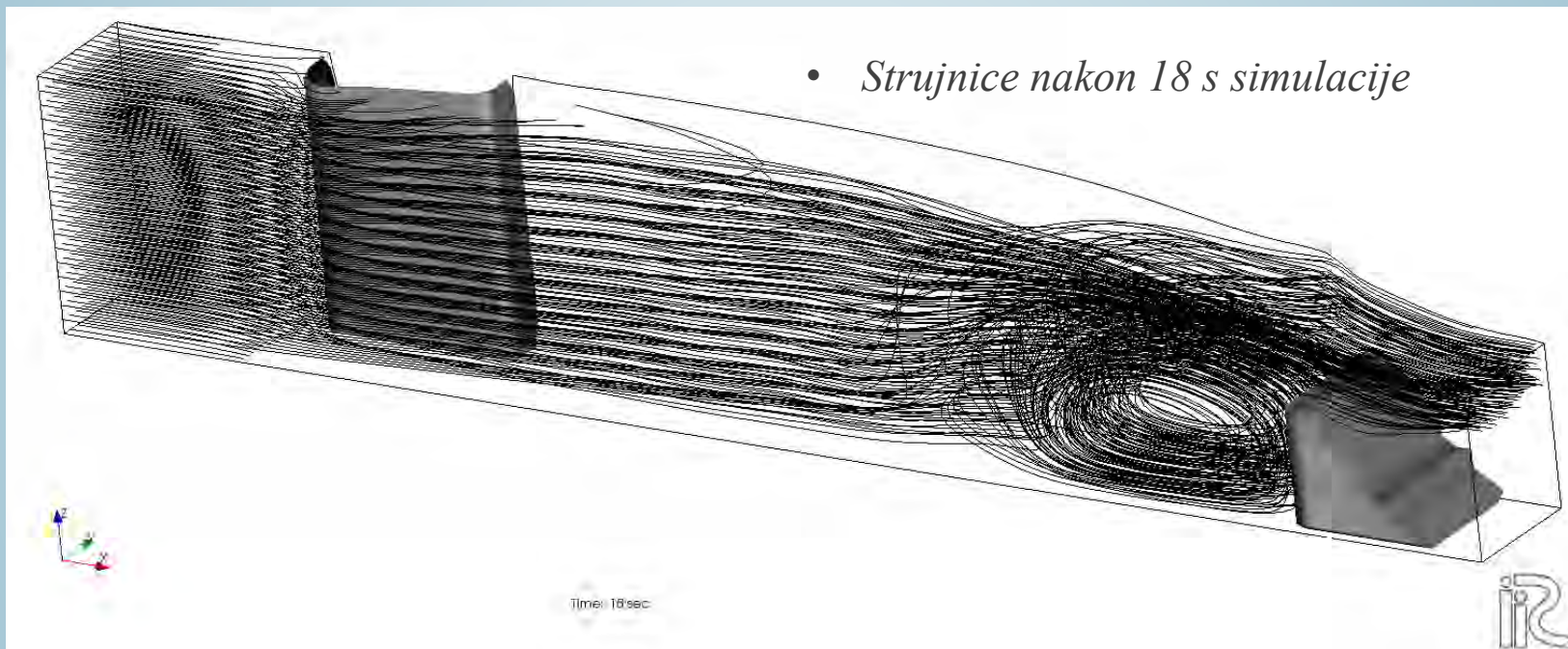
- *Kretanje vode po površini vode na kraju simulacije*





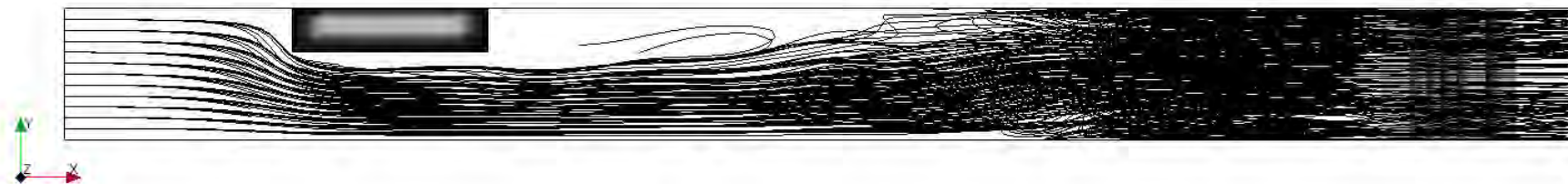
Time: 2 sec

- *Strujnice nakon 2 s simulacije u osnovi*



Time: 18 sec

- *Strujnice nakon 18 s simulacije*



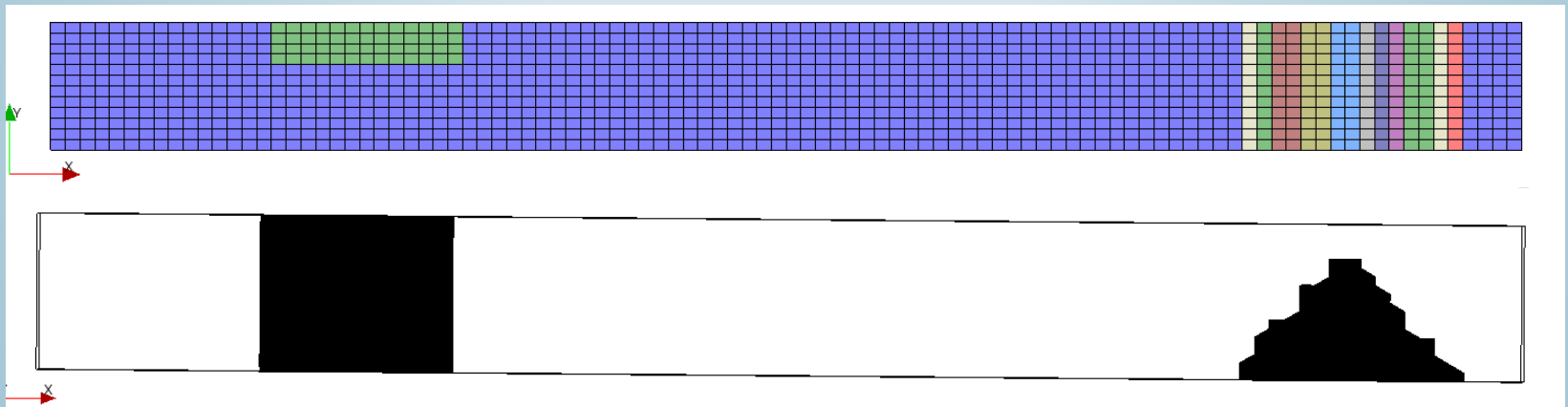
Time: 18 sec

- *Strujnice nakon 18 s simulacije u osnovi*



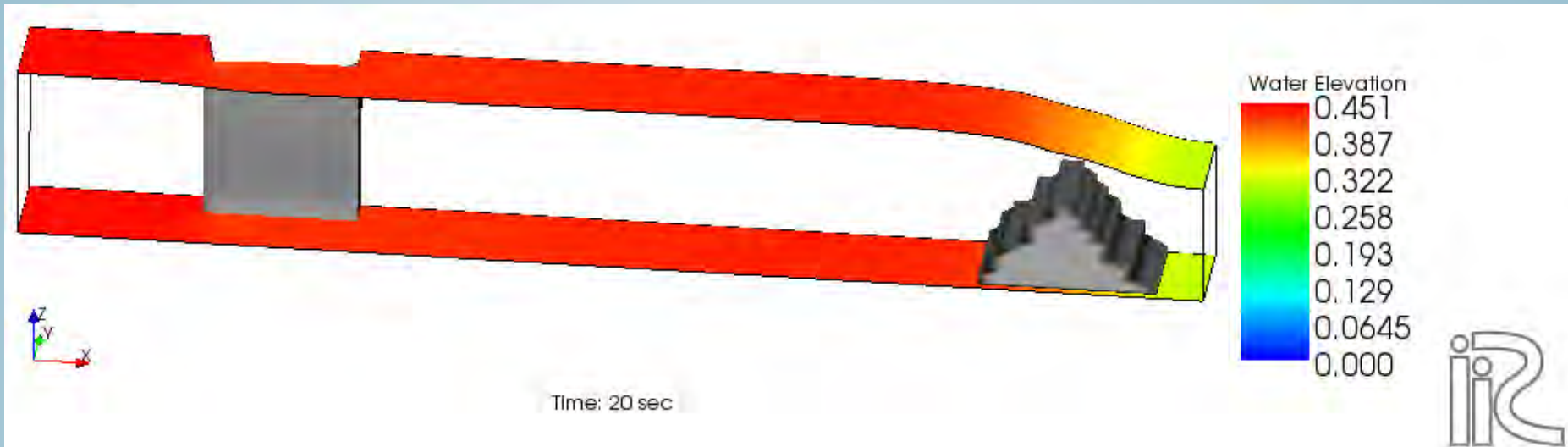
Druga varijanta modela:

- Zbog postojećih vrtloga uzvodno od preliva, napravljen je model sa stepenastom uzvodnom ivicom preliva*
- Svi parametri proračuna su ostali isti*

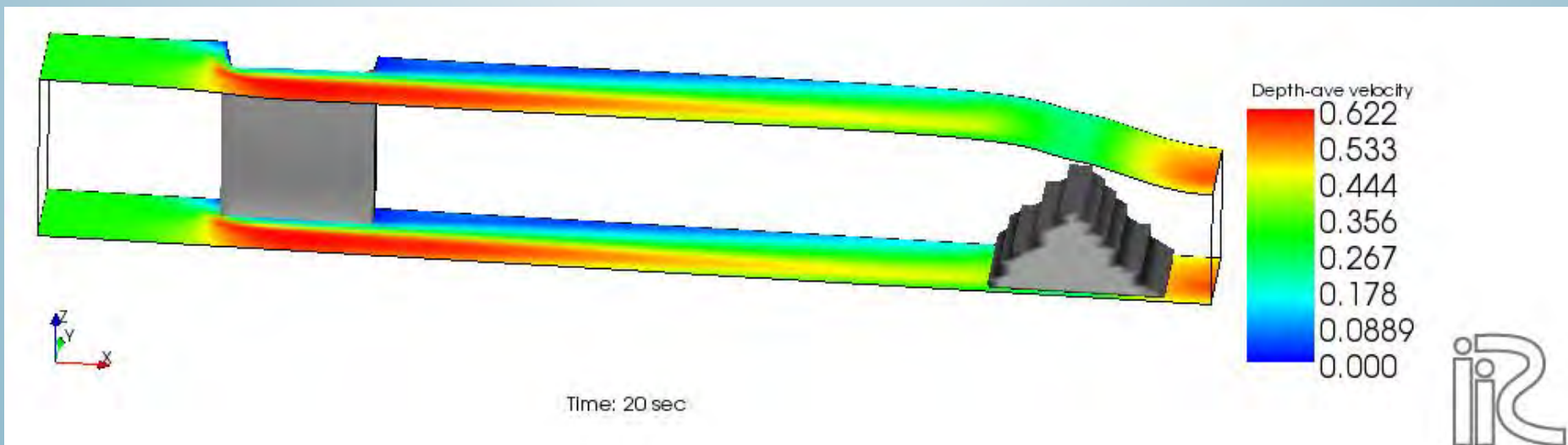


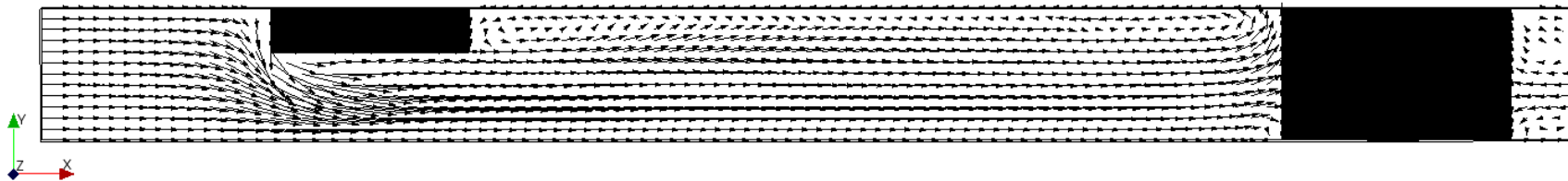
Druga varijanta modela - rezultati:

- *Nivo vode u kanalu na kraju simulacije*

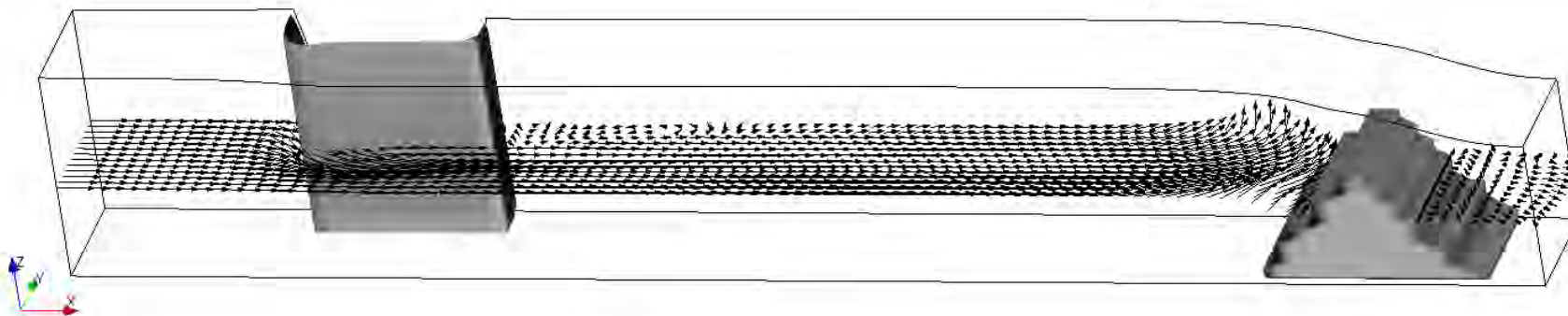


- *Brzinska visina u kanalu na kraju simulacije*

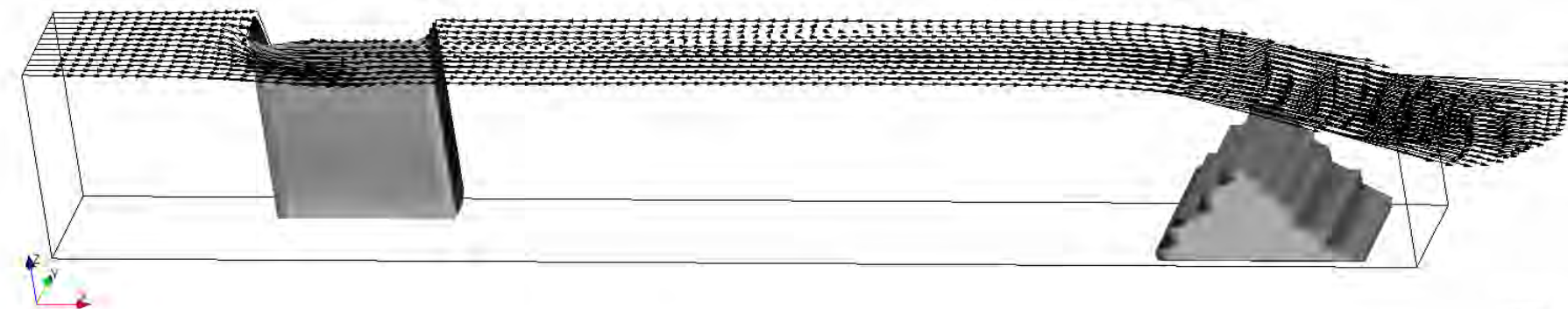




- *Kretanje vode po dnu kanala* Time: 20 sec

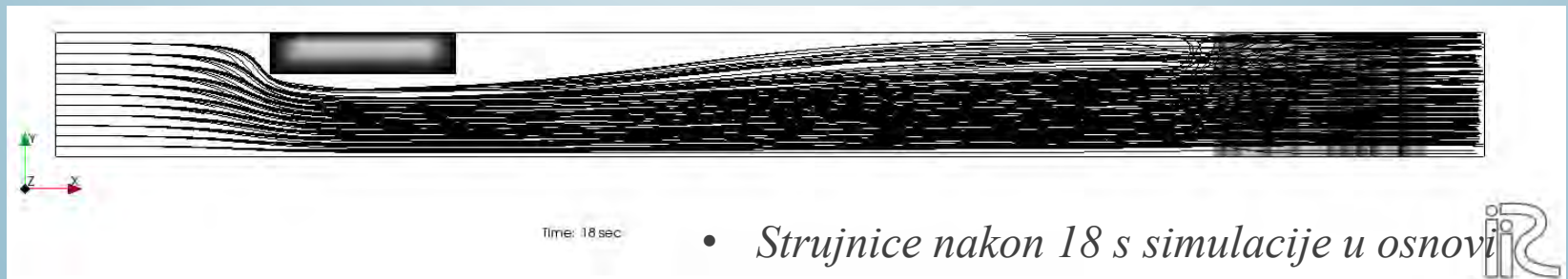
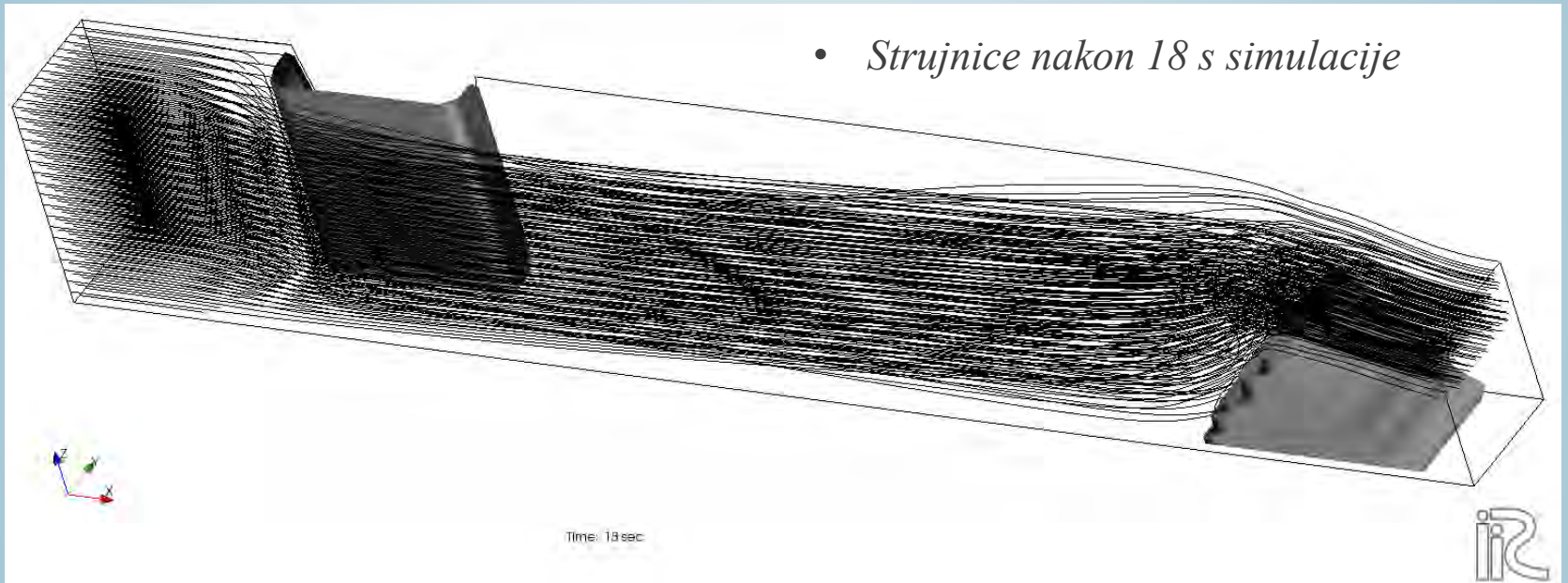
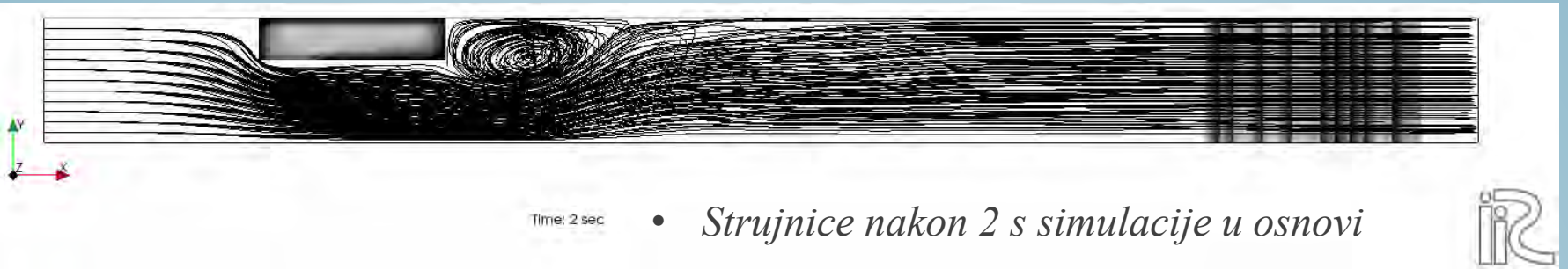


- *Kretanje vode po sredini dubine vode* Time: 20 sec

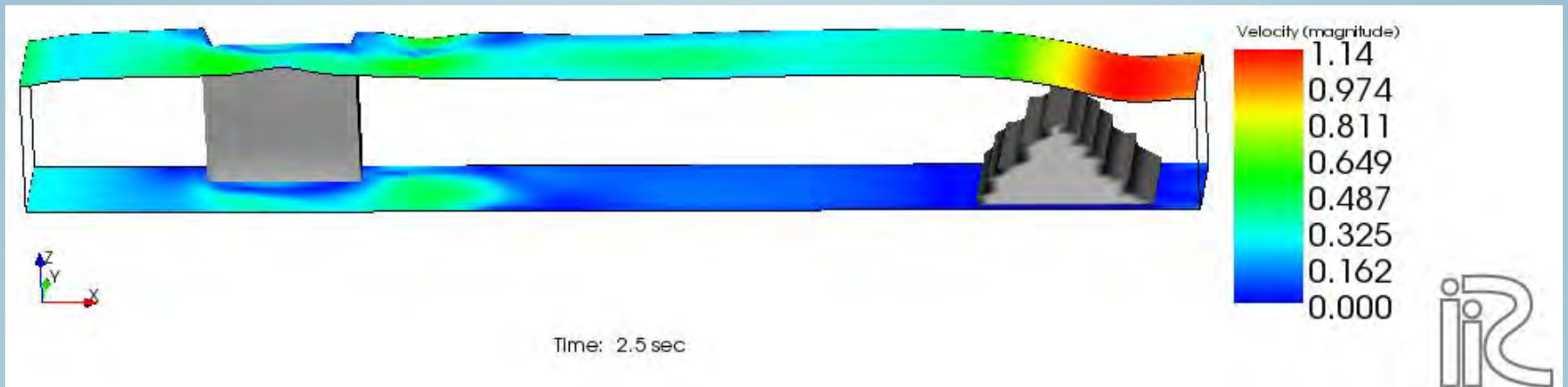


- *Kretanje vode po površini vode* Time: 20 sec

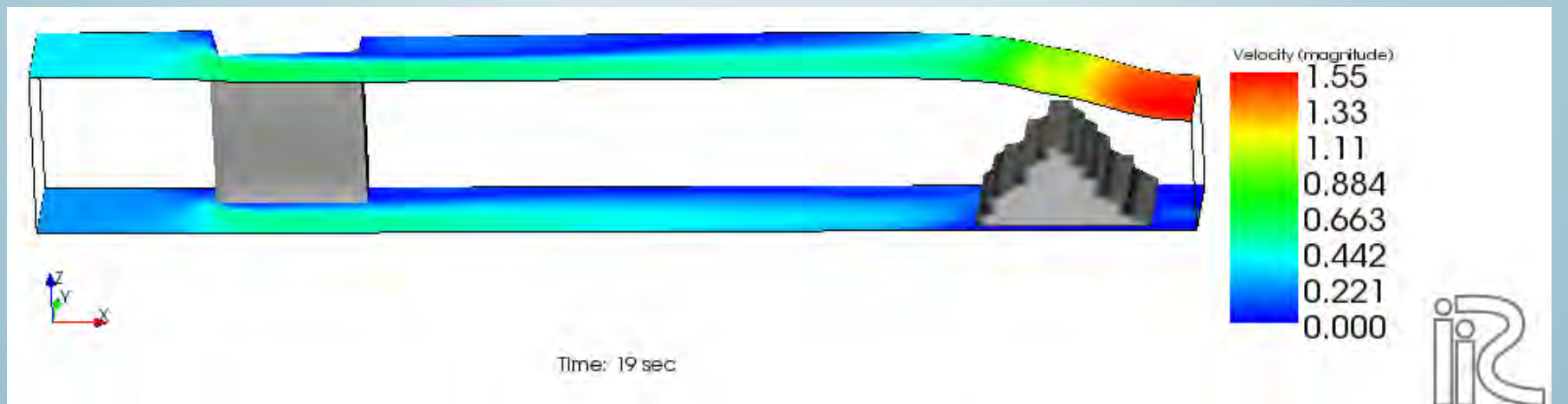




Druga varijanta modela - rezultati:



- *Brzina vode u kanalu nakon 2,5 s simulacije*



- *Brzina vode u kanalu na kraju simulacije*

- *Dijagram brzine vode na površini po dužini kanala u preseku uz prepreku*

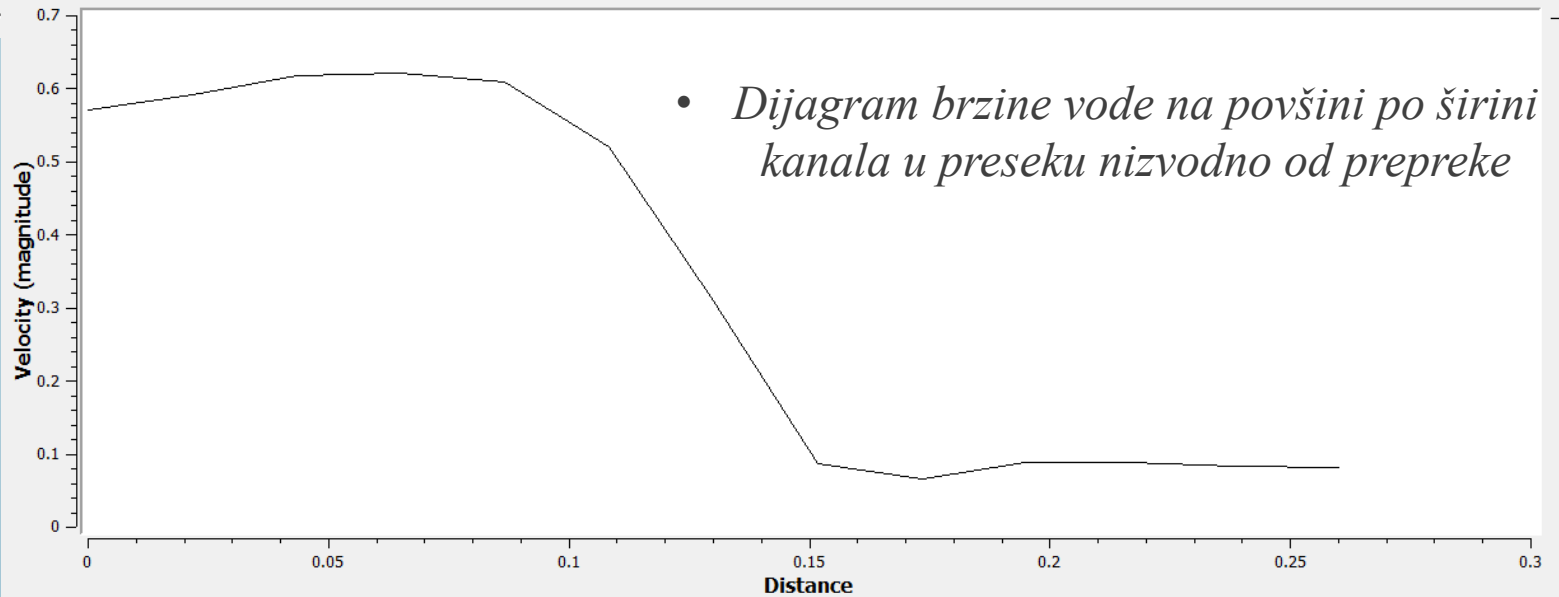


Controller

J:

K:

9



- *Dijagram brzine vode na površini po širini kanala u preseku nizvodno od prepreke*

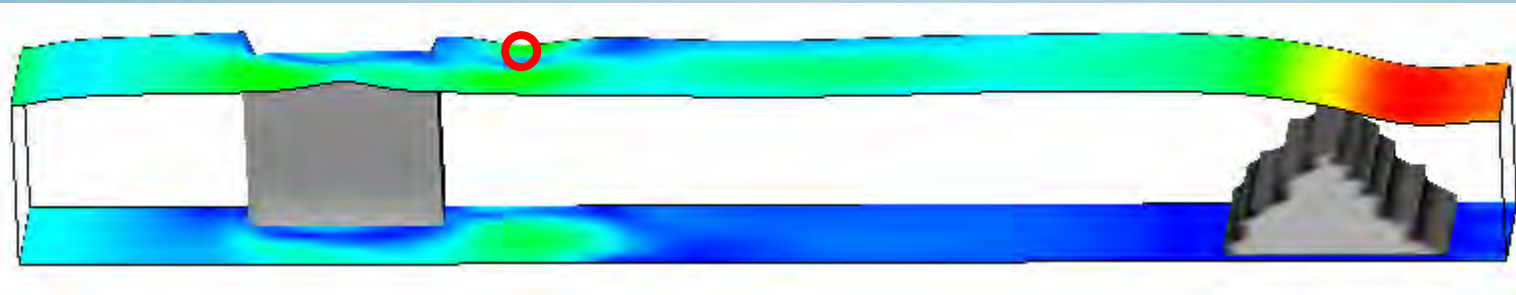
Controller

I:

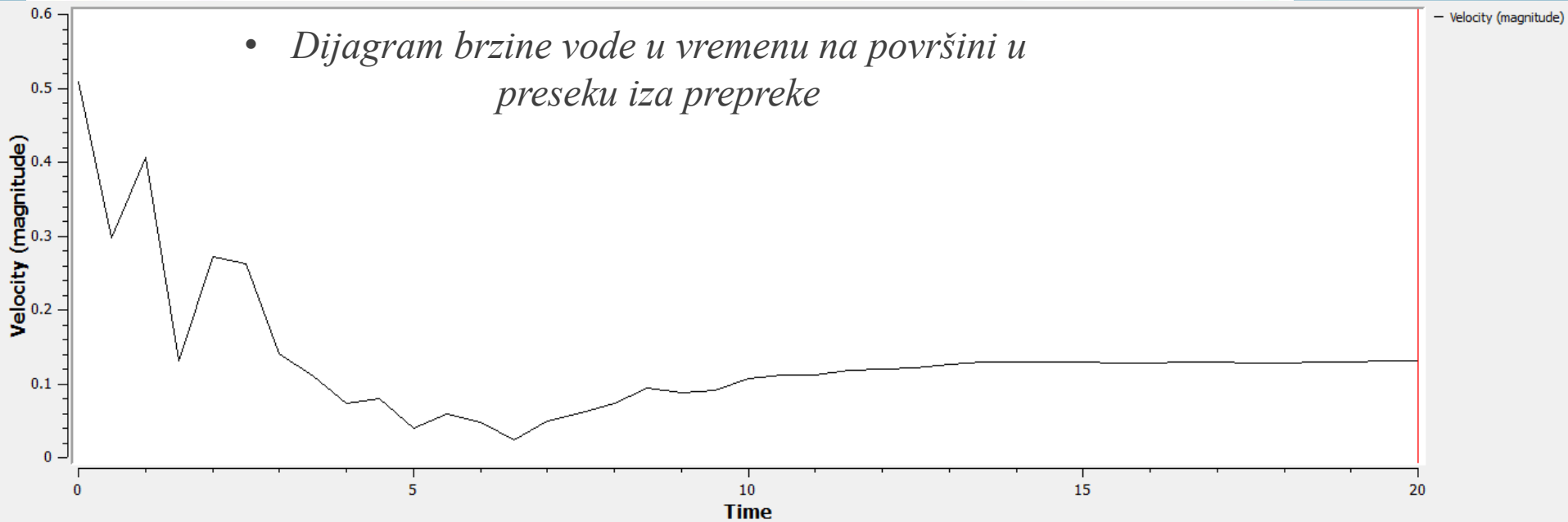
K:

30

19



- *Dijagram brzine vode u vremenu na površini u preseku iza prepreke*

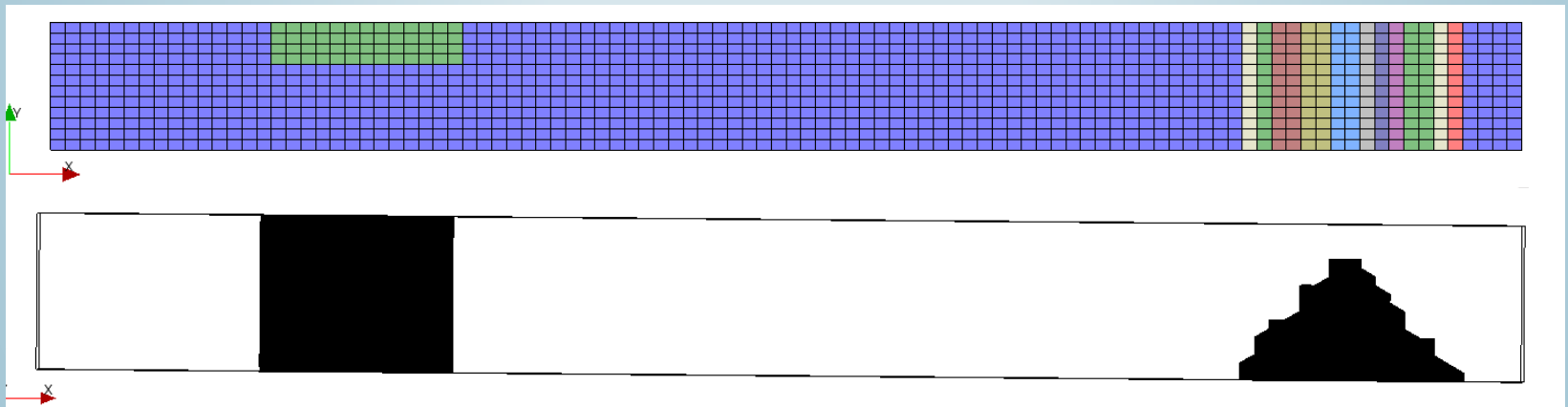


Controller



Nelinearni proračun drugog modela:

- Radi upoređivanja rezultata i rada linearnog i nelinearnog modela, urađen je proračun nelinearnog modela.*
- Svi ostali parametri ostali su isti kao i na prethodnom modelu*

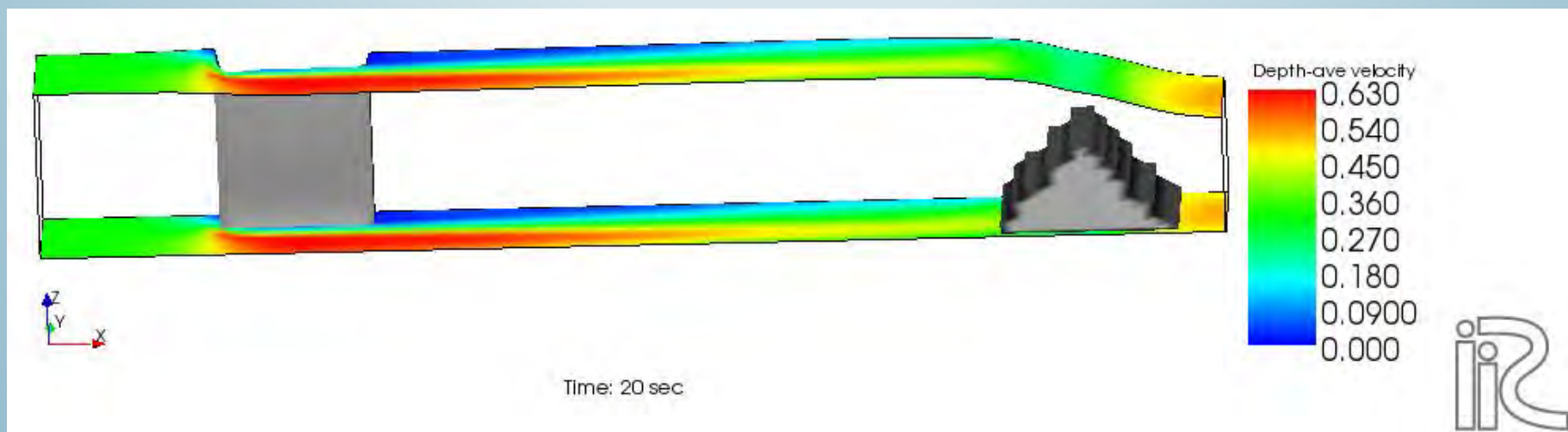


Nelinearni proračun drugog modela - rezultati:

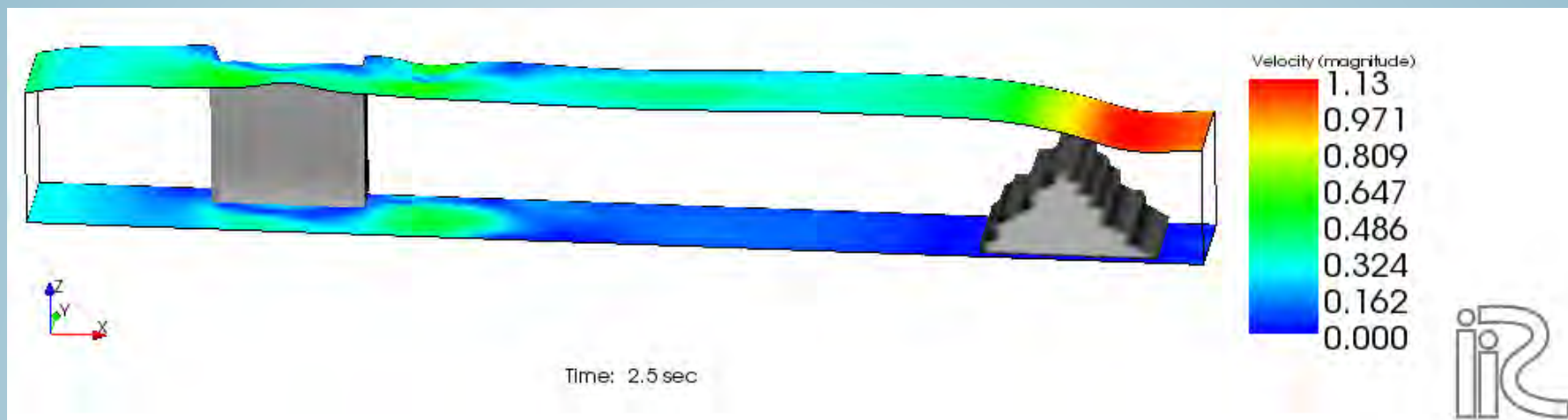
- Nivo vode u kanalu na kraju simulacije*



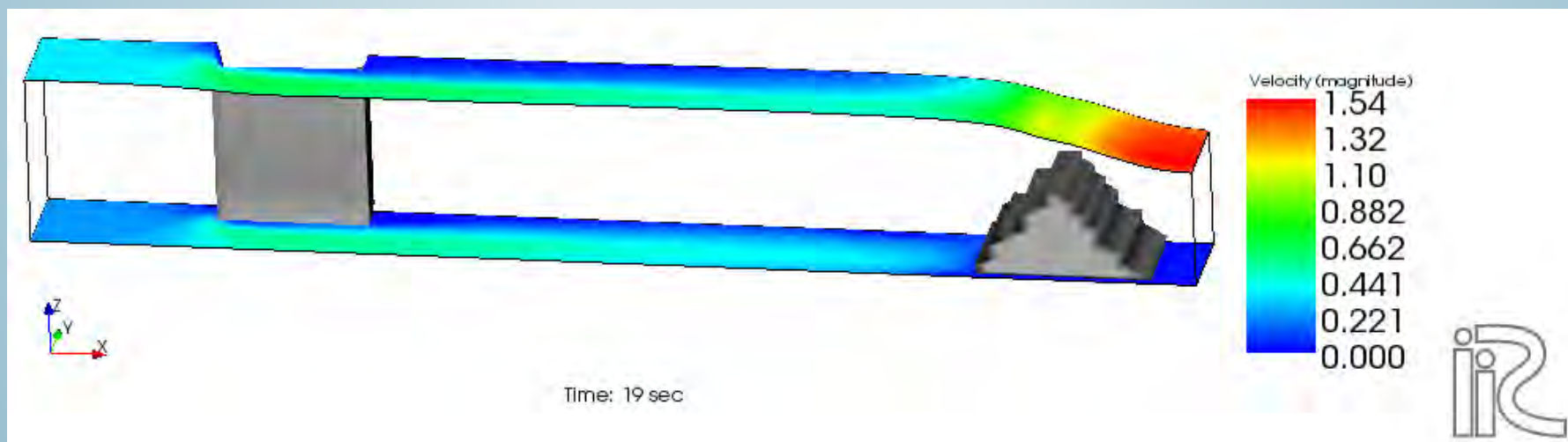
- Brzinska visina u kanalu na kraju simulacije*



Nelinearni proračun drugog modela - rezultati:



- *Brzina vode u kanalu nakon 2,5 s simulacije*



- *Brzina vode u kanalu na kraju simulacije*

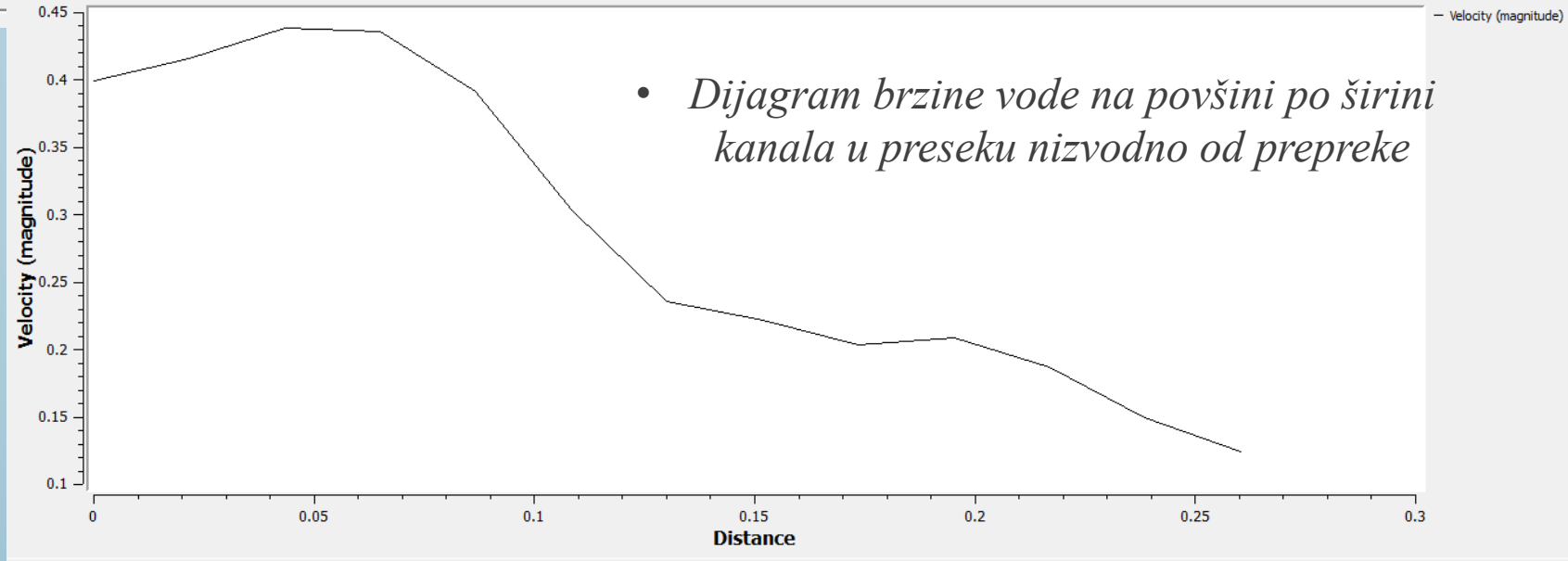


Controller

J: _____

K: _____

9



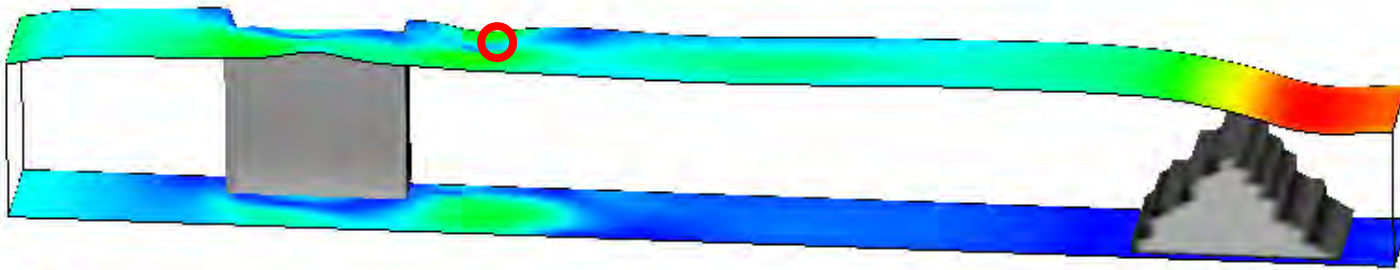
Controller

I: _____

K: _____

30

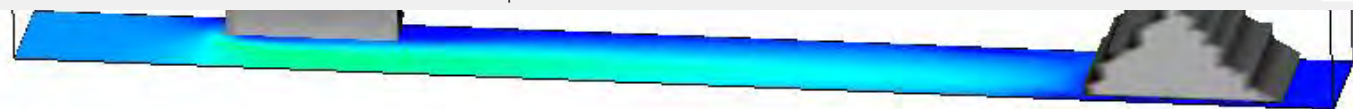
19



- *Dijagram brzine vode u vremenu na površini u preseku iza prepreke*



Controller



Time: 19 sec

Zaključak:

- **Model sa ravnom uzvodnom ivicom preлива:**
 - Nizvodno od prepreke se na početku simulacije stvaraju vrtlozi, koji se kroz vreme gube
 - Kroz vreme, brzine se smanjuju
 - Preliv je uspeo da napravi uzvodno konstantan nivo vode, ali neposredno uzvodno od preлива stvaraju se vrtlozi
- **Model sa stepenastom uzvodnom ivicom preлива:**
 - Maksimalan nivo vode u kanalu se smanjuje
 - Maksimalna brzina vode u kanalu se smanjuje
 - Gube se vrtlozi uzvodno od preлива
 - Brzina vode je najveća na prelivu
 - Male brzine vode nizvodno od prepreke
- **Model sa nelineranim modelom proračuna:**
 - Nivo vode se neznatno razlikuje od modela sa linearnim proračunom
 - Dijagram brzine vode oko prepreke se razlikuje od modela sa linearnim modelom proračuna, oscilacije su izraženije
 - Na prikazu strujnica vode nema značajnih razlika

Zaključak:

Zaključak o programu

- *Jasan prikaz veličina u kanalu*
- *Mogućnost prikaza dijagrama kroz vreme ili u određenom pravcu*
- *Mogućnost postavljanja različitih prepreka*
- *Jasna slika tečenja u kanalu uz pomoć strujnica*
- *Mogućnost praćenja promena u kanalu tokom simulacije*
- *Ukoliko se zadaju neodgovarajući parametri, proračun prijavljuje grešku*
- *Ukoliko se zada preveliki vremenski korak, proračun je nestabilan i prijavljuje grešku*
- *Ukoliko je potrebno, za detaljniji proračun, moguće je zadati gušću grid mrežu ili manji vremenski korak*

- *Nije moguće promeniti grid mrežu nakon što je jednom zadata*

- *Ukoliko se zada predugačka simulacija, a laptop nije dovoljno jak, program je opasan po njega... 😊*



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Doktorske studije 2017/18

Odsek za hidrotehniku i vodno – ekološko inženjersktvo

Mehanika fluida, napredni kurs

Hvala na pažnji !

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