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Experimental study the effect of turbulent flows in bend channels as to a result of vegetation groin structure on permeable type

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Abstract. Highly dynamic changes in flow regimes are caused by relatively high rainfall intensity, so that the excessive flood volume in the last ten years, and it is caused by watersheds experiencing a crisis or degradation due to conversion into economic and non-economic areas which ultimately impacts on river bank and beds by turbulent flow. The use of groin structure as a method of scouring prevention and channel flow control has not been able to fully meet the expectations of scouring prevention. We obtain the effect of changing the turbulent flow regime on the use of groins on the bent channel. Testing was conducted through laboratory experiments in artificial conditions to investigate the relationship between variables by providing certain treatments in several experimental groups with a comparative control of bend channel angle uses 60° with distance variations of groins and discharge; in addition, software *Surfer* used to describe scour contour pattern. Analysis of changes in flow behavior is done by using *Froude* (Fr) and *Raynolds* (Re) number approaches with the effect of turbulent flow on the bent channel scour. The results of the research indicate that the placement of the groins on the river bank channel bend causes a new phenomenon of turbulent flow with shear stress, resulting in local scouring around groin structure and the placement of looser permeable groin gives prevention 81% of river bank scour.

1.Introduction

Scouring on river banks usually becomes a problem, and until now it has not obtained an appropriate method that effectively prevents scouring on river bank bends. Efforts to control and secure the river can be done along the river in various ways, including by strengthening the bank by installing groins that are placed outside the river bends, but in fact it has not been successful even causing a new problem in the bend area with relatively high velocity by the changes of climate and trigger the critical velocity and shear stress in the bend area.

The dynamics of flow on channel bends causes sediment erosion of channel bank. The characteristics of flow contribute very high to the sediment erosion and deposition; hence the use of flow control structures is needed to minimize the effect of sediment flow and sediment erosion in rivers [1]. Flow control and scour prevention by using groins in 2 (two) forms, i.e straight and T-shaped groins can regulate and reduce scouring around the groins but it still requires testing of groins



variations [2]. Permeable groin protects the bank against the scouring of river flow by reducing the energy contained in the flow along the river bank and can deposit sediment [3].

The use of groin method inflow control can prevent scour and deposit sediment around the groin. Vegetation groin is good for flow resistance, rigid and flexible as energy reducer [4]. Also, the groin is widely used to maintain river bed morphology in the context of river activities [5]. The research in 2016 gives the main conclusions as follows; (a) the use of vegetation groin significantly reduces the magnitude of flow velocity, (b) causing the dynamics of shear layers on the land surface, main flow, and soil, (c) the vegetated dynamics of groin flow can be modeled and good enough to develop analytical relationships at a limited size [6].

The construction of groin triggers the phenomenon of turbulent flow; it is related to what has been stated by some previous experts that the characteristic of turbulence flow has long been studied by scientists and engineers. Leonardo da Vinci saw a typical whirlpool by turbulence as contained in the book of Tennekes and Lumley [7]. The phenomenon of that turbulent flow states that turbulent flow can cause scouring on river banks or beds. Turbulent flow is highly dynamic therefore it requires understanding the characteristic of turbulent flow as the main focus, as it can cause friction. As a result of this friction is the cause of the channel erosion. We investigate the distribution of turbulent flow velocity by using corals as a turbulent flow structure using Particle Image Velocity (PIV) and The Large-Eddy Simulation (LES) to describe the phenomenon of turbulent flow velocity [8]. The problem of turbulent flow becomes a problem in control the scouring around riverbanks by either using conventional groin or vegetation groins such as bamboo or wood.

2. Methods and materials

Testing was conducted at the River Laboratory of the Faculty of Engineering, Muhammadiyah University of Makassar and it was conducted between February - March 2019, a model used as showed in figure 1, figure 2 and figure 3.

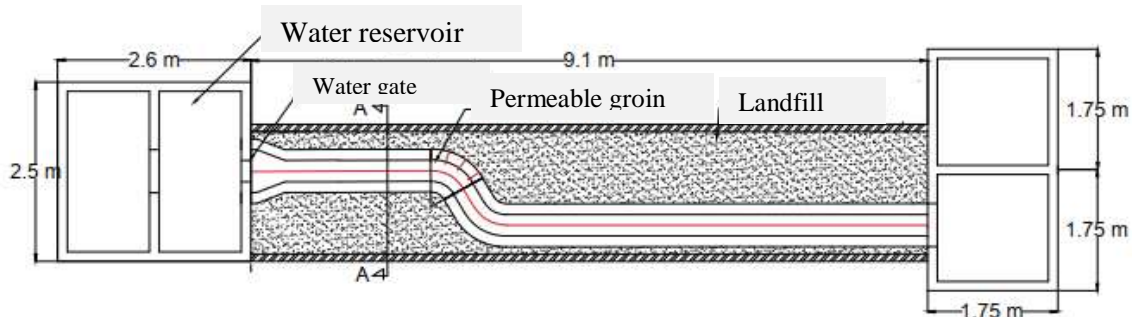


Figure 1. The layout of the channel plan.

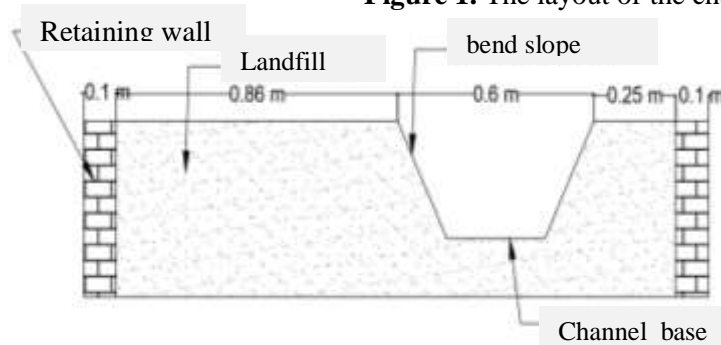


Figure 2. Channel cross section.

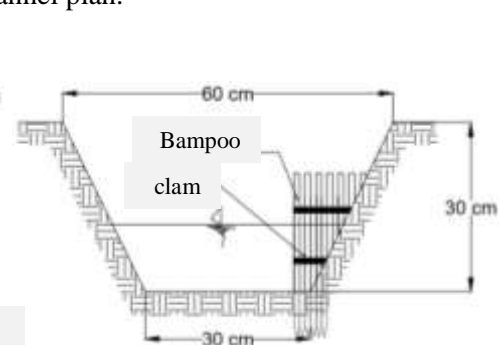


Figure 3. Channel detail.

Testing was done by laboratory experiments on artificial conditions, to investigate the relationship between variables and giving certain treatments to several experimental groups with comparative

control. Permeable groin material used is bamboo and data includes river flow velocity and scour volume on discharge variations at channel bend angle 600. The approaches used in this research are Raynolds (Re) and Froude (Fr) number, in addition, we use software Surfer to describe scour contour pattern.

3. Results and discussion

3.1 Characteristic of channel flow in channel bend scour

The result shows that the increase in discharge is directly proportional to the flow velocity and turbulent flow as flow energy is relatively high to erode the bend of the channel. The function of the groin as a flow regulator and scour prevention is depicted on the observation result of channel bends with the groin structure and without groin can increase the value of turbulent flow for the distance between groin 0.35 m far around 09.28% to 15.59% [9]. While the denser distance of the groin structure is 0.15 m it can reduce the value of turbulent flow around 1.10% to 3.43%. it is inversely proportional to the increase in the value of turbulent flow that can reduce the riverbank scour at the channel bend around 71.11% to 81.73%, means it has relatively better performance, while the value of turbulent flow with smaller decreases can reduce scours around 36.15% to 56.79%. As shown in table 1 and table 3. It is estimated that the turbulent flow factor that gives energy shear stress to the material of the channel bend bank, it causes local scours, according to the theory to reduce the shear stress in the open channel has been tested that the configuration of good groin distance for reducing the pressure on the channel wall can reduce scour on the channel wall [10]. It gives an illustration that the placement of the distance between the groin structure with others become main focus, this is due to the more distance inter-groin then denser, and it shows the decrease of turbulent flow although the effectiveness of scouring prevention is only up to around 56.79%, when compared to the far distance of groin is looser up to 81.73%. This difference is caused by a new phenomenon of turbulent flow and causes local scouring around the groin structure, it is in accordance with the theory that the groin construction can trigger the phenomenon of turbulent flow, this is related to what has been stated by some previous experts that the characteristic of turbulence flow has long been studied by scientists and engineers. Leonardo da Vinci saw a typical whirlpool of turbulence as contained in the book of Tennekes and Lumley.

Table 1. Characteristic of flow according to Raynolds (Re) number.

Groin (m)	Distance	Discharge (m ³ /dt)	Flow velocity (m)	Water depth (h, m)	Cross section area (A, m ²)	Raynolds number (Re)	Reduction Percentage (%)	Flow characteristic
Without Groin			0.778	0.074	0.025	50008.97	-	Turbulent
0.35		0.0044	0.726	0.095	0.033	57526.86	15.03	Turbulent
0.25			0.670	0.095	0.033	52230.76	02.74	Turbulent
0.15			0.633	0.092	0.032	49456.38	01.10	Turbulent
Without Groin			0.884	0.074	0.028	59885.55	-	Turbulent
0.35		0.0086	0.796	0.098	0.034	65443.02	09.28	Turbulent
0.25			0.756	0.099	0.034	59408.85	01.47	Turbulent
0.15			0.715	0.097	0.034	58459.25	02.38	Turbulent
Without Groin			0.970	0.082	0.028	69177.38	-	Turbulent
0.35		0.0145	0.889	0.098	0.034	79964.05	15.59	Turbulent
0.25			0.837	0.100	0.035	71096.74	02.29	Turbulent
0.15			0.796	0.092	0.032	66805.62	03.43	Turbulent

Flow velocity in the groin structure with a longer distance (0.35 m) does not provide a significant

velocity reduction because it only ranges from 12.52 to 27.60%. Conversely, at a denser distance (0.15 m) the effect of a greater flow velocity around 10.85 to 21.84%. This means that the placement of inter-groin distance can greatly influence the channel flow control as one of the groin functions, see table 2. The scour prevention on the channel riverbank bend can be shown a greater inter-groin distance that is denser (0.15 m) ranging from 36.15% to 56.79 %, see table 3. The performance of groin placement has not reached 100%, it is caused by a new phenomenon of turbulent flow which causes local scouring around the groin structure. A theory that the groin construction can trigger the phenomenon of turbulent flow; it is related to what has been stated by some previous experts that the characteristic of turbulence flow has long been studied by scientists and engineers. Leonardo da Vinci saw a typical whirlpool of turbulence as contained in the book of Tennekes and Lumley [11].

Table 2. Characteristic of flow according to *Froude* (Fr) number.

Groin (m)	Distance	Discharge (m ³ /dt)	Flow velocity (m)	Water depth (h, m)	Cross section area (A, m ²)	Raynolds number (Re)	Reduction Percentage (%)	Flow characteristic
Without Groin			0.778	0.074	0.025	0.915	-	Critical
0.35		0.0044	0.726	0.095	0.033	0.753	12.52	Critical
0.25			0.670	0.095	0.033	0.812	08.44	Critical
0.15			0.633	0.092	0.032	0.908	10.85	Critical
Without Groin			0.884	0.074	0.028	0.941	-	Critical
0.35		0.0086	0.796	0.098	0.034	0.695	24.08	Critical
0.25			0.756	0.099	0.034	0.769	18.04	Critical
0.15			0.715	0.097	0.034	0.845	21.30	Critical
Without Groin			0.970	0.082	0.028	1.086	-	Critical
0.35		0.0145	0.889	0.098	0.034	0.662	27.60	Critical
0.25			0.837	0.100	0.035	0.735	21.69	Critical
0.15			0.796	0.092	0.032	0.842	21.84	Critical

Table 3. Recapitulation of scours volumes for various research simulations.

Groin (m)	Distance	Discharge (m ³ /dt)	Flow velocity (m)	Water depth (m)	Scour volume (Vg, m ³)	Reduction volume (Vg, m ³)	Scour Percentage (%)
Without Groin			0.778	0.074	0.00752	-	-
0.35		0.0044	0.726	0.095	0.00567	0.00185	75.40
0.25			0.670	0.095	0.00391	0.00361	51.99
0.15			0.633	0.092	0.00322	0.00245	56.79
Without Groin			0.884	0.074	0.00761	-	-
0.35		0.0086	0.796	0.098	0.00513	0.00193	81.73
0.25			0.756	0.099	0.00401	0.00304	64.52
0.15			0.715	0.097	0.00288	0.00334	46.30
Without Groin			0.970	0.082	0.0117	-	-
0.35		0.0145	0.889	0.098	0.00832	0.00338	71.11
0.25			0.837	0.100	0.00614	0.00556	52.48
0.15			0.796	0.092	0.00423	0.00832	36.15

3.2 Scouring pattern of riverbank bend with surfers

Formation of the scouring contour pattern is depicted using surfers both before and after the groin structure, as shown in figure 4, figure 5 and figure 6.

In figure 4, figure 8 and figure 12 show that scour without groin looks more looser contours as a result of the occurrence of larger scour and it is influenced by high-flow velocity pressure, as well as it is explained in theory that the occurrence of riverbank erosion is caused by shear stress due to high flow velocity and humidity conditions to hold the soil stable while soil moisture is highly increasing [12].

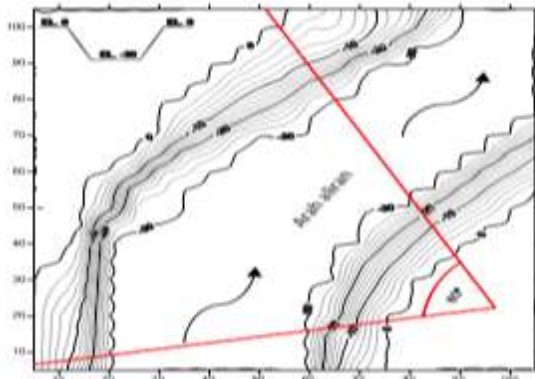


Figure 4. Scour contour without groin at discharge $Q_3 = 0.0145 \text{ m}^3/\text{s}$.

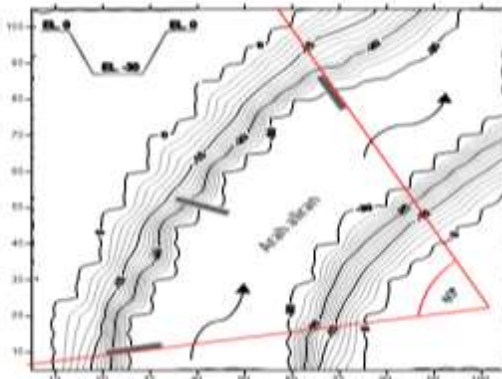


Figure 5. Scour contour of the riverbank with groin 35 cm distance at discharge $Q_3 = 0.0145 \text{ m}^3/\text{sec}$.

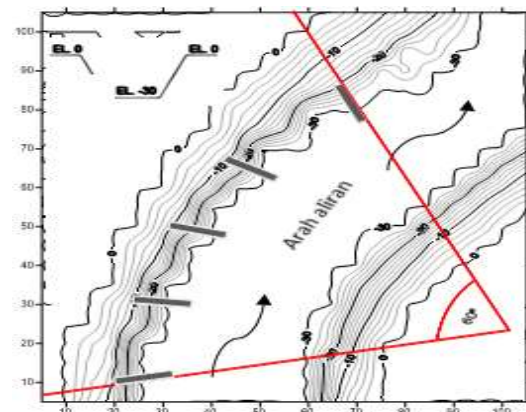


Figure 6. Scour contour of the riverbank with groin 25 cm distance at discharge $Q_3 = 0.0145 \text{ m}^3/\text{sec}$.

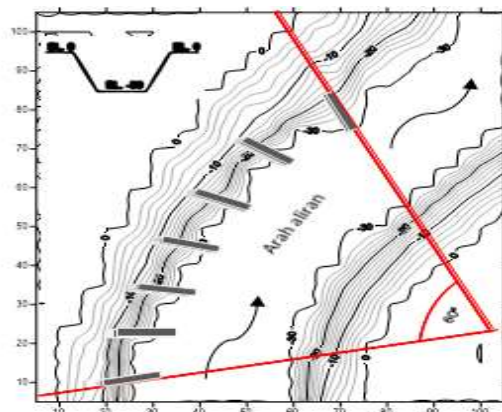


Figure 7. Scour contour of the riverbank with groin 15 cm distance at discharge $Q_3 = 0.0145 \text{ m}^3/\text{sec}$.

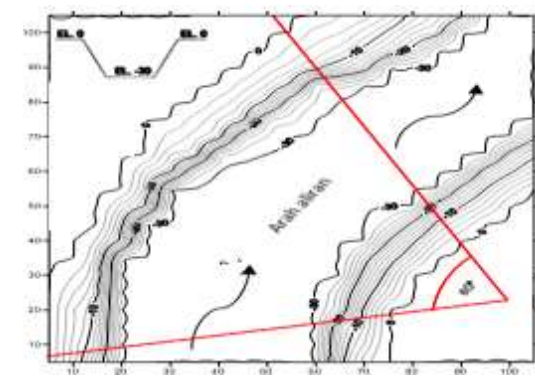


Figure 8. Scour contour of riverbank without groin at discharge $Q_3 = 0.0086 \text{ m}^3/\text{sec}$.

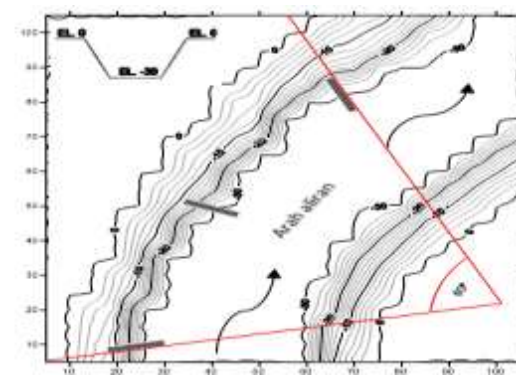


Figure 9. Scour contour of the riverbank with groin 35 cm distance at discharge $Q_3 = 0.0086 \text{ m}^3/\text{sec}$.

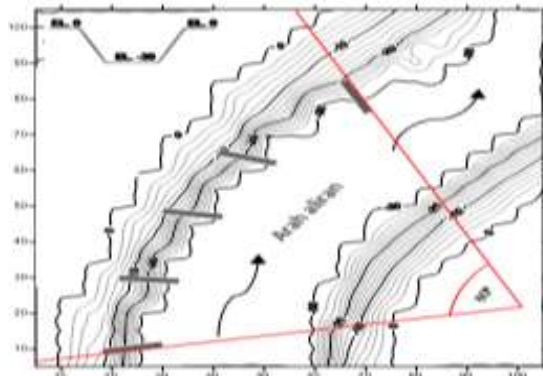


Figure 10. Scour contour of the riverbank with groin 25 cm distance at discharge $Q_3 = 0.0086 \text{ m}^3/\text{sec}$.

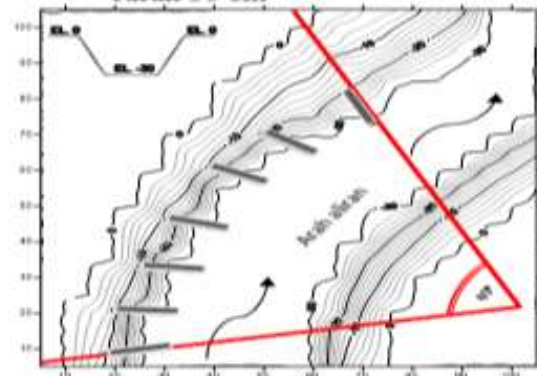


Figure 11. Scour contour of the riverbank with groin 15 cm distance at discharge $Q_3 = 0.0086 \text{ m}^3/\text{sec}$.

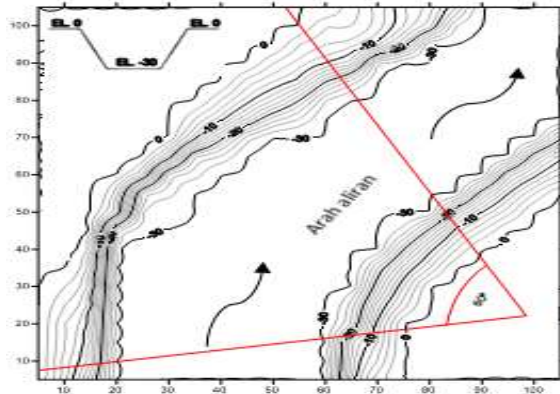


Figure 12. Scour contour of riverbank without groin at discharge $Q_1 = 0.0044 \text{ m}^3/\text{sec}$.

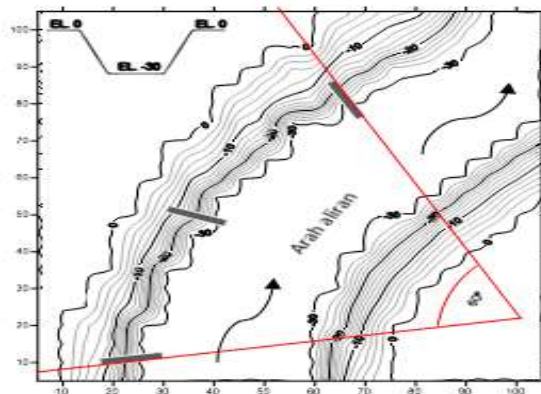


Figure 13. Scour contour of the riverbank with groin 35 cm distance at discharge $Q_1 = 0.0044 \text{ m}^3/\text{sec}$.

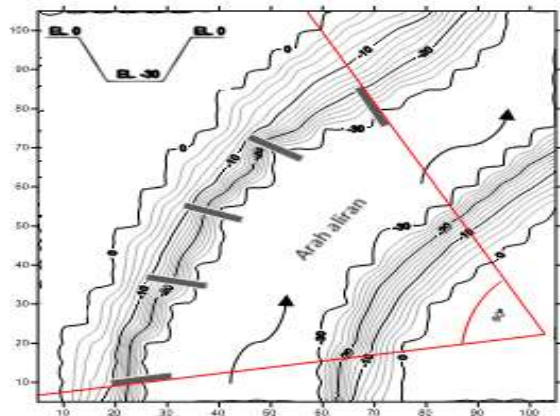


Figure 14. Scour contour of the riverbank with groin 25 cm distance at discharge $Q_1 = 0.0044 \text{ m}^3/\text{sec}$.

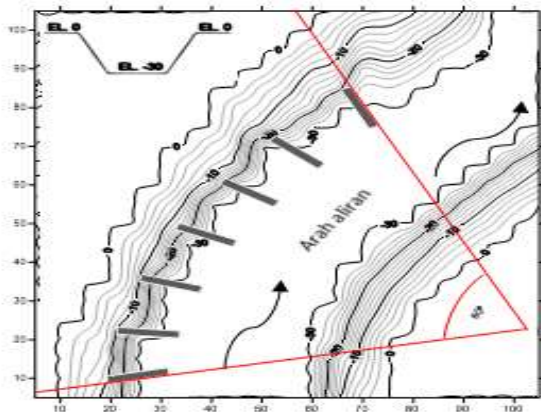


Figure 15. Scour contour of the riverbank with groin 15 cm distance at discharge $Q_1 = 0.0044 \text{ m}^3/\text{sec}$.

The results show that this sign is seen in the looser distance of the groin as used in laboratory testing was 15, 25 and 35 cm, it turns out that the looser distance of the groin is 35 cm, it gives

significant results as shown in figures 6, 10 and 14 with denser scour contours as a result of scour decrease and prevention by using groin as its function, by significant result it can decrease until over 81% as shown in table 3 above as a result of observations in laboratory testing. It can also provide an illustration that the increasingly looser distance between the groin, the effectiveness of the function of permeable groin is better and conversely the denser distance of the groin, the function of permeable groin is less satisfied as result of local scouring around the groin which is affected by shear stress of the groin density and an increase in shear pressure one another. The occurrence of this difference is caused by a new phenomenon of turbulent flow and causes local scouring around the groin structure, this is in accordance with the theory that the groin constructing actually triggers the phenomenon of turbulent flow, this is related to what has been stated by some previous experts that the characteristic of turbulence flow has long been studied by scientists and engineers. Leonardo da Vinci saw a typical whirlpool of turbulence as contained in the book of Tennekes and Lumley.

4. Conclusions

- Placement of groin on the channel bends causes new phenomena of turbulence flow, shear stresses and local scouring;
- Permeable-type groin using bamboo with not too denser distance (35 cm) gives scouring prevention up to 81% in performance and for denser distance (15 cm) gives 50% in performance.

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